Delbos, L.
Metric system. - 1900.

THE METRIC SYSTEM

THE METRIC SYSTEM

A PRACTICAL MANUAL

WITH NUMEROUS EXAMPLES

BY

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PREFACE

If an apology were wanted for the publication of such a work as the one now offered to the English public, I should find it in the fact that, although the present cumbrous system of English weights and measures is not likely to be displaced for some time to come, yet the metrical weights and measures are now so generally used abroad, that business men having transactions with foreign firms can no longer dispense with a knowledge of the Metric System. It is chiefly for those that the present work has been undertaken.

Had it fallen to the lot of some other person to write the following pages, it is quite possible that this book might have reached a higher standard of excellence; yet I cannot help thinking that for practicalness, and clearness, it will hold its own against some of its present competitors. At any rate, it should do so, since I have had an advantage over most—perhaps all—who have treated the same subject. This advantage lies in the fact that both the English system of weights and measures, and the Metric System, have long been equally familiar to me, and that it has been my good fortune to instruct children in both systems, as well in England as abroad.

Although this book is primarily intended for practical men of business, yet as the opponents of the Metric

System have often recourse to the most futile arguments to demonstrate the superiority of the present English system of weights and measures over other systems, I have deemed it necessary to devote a chapter to "The Advantages and Disadvantages of the Metric System," and I hope I have succeeded in proving conclusively that the arguments adduced by the adversaries of the system are more specious than sound.

As for the other portions of the book, the headings of the various chapters will speak sufficiently for them, without it being necessary to enter here into any particulars about them. It will suffice to say that my aim throughout has been to explain everything, and to make things as clear as possible.

My task is now done, and, on the eve of my work being submitted to the public, I cannot help saying, as a parting word, that the composition of this little book has been a source of true pleasure to me, because, rightly or wrongly, I have complacently imagined that it might be a new link, though a very small one, in the chain which ought to unite two countries which, more than all others, have unceasingly worked to break down the barriers which have so long obstructed the progress of mankind.

L. D.

DARTMOUTH

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CHAPTER I.

HISTORICAL INTRODUCTION ON THE METRIC SYSTEM

FOR many, very many years, the systems of weights and measures in use among the different nations of the world were at least as numerous as the various languages spoken by them; nay, they were probably more so, for there was a time when not only every country, but even every province and district, had its own particular way of measuring and valuing things. The inconvenience arising from such a multiplicity of standards of weights and measures did not certainly fail to be understood by people; nevertheless, commercial transactions remaining within very moderate limits, and the intercourse between the people of one country and the inhabitants of another being a matter of great difficulty, the inconvenience was not severely felt. However, with the spread of commerce and with increased means of communication, the inconvenience became more and more apparent, and so much so that it became finally imperative on rulers to put a stop to a state of affairs which was highly detrimental to the commercial interest of the people themselves. This inconvenience was recognised very long ago, since we find that, as early as the days of Charlemagne (768–814), a reform had been proposed, the object of which was the unification of weights and measures throughout the Western Empire.

Unfortunately, the means of communication were then so few and so bad, and commerce so insignificant a thing, that nothing came of the project. Nevertheless, the idea was not entirely abandoned, and the more intelligent persons were

not slow in understanding that a reform in the proposed direction would be a public benefit, and that it might possibly be also one of the means of promoting the interests of commerce. At length, after many unsuccessful attempts, and as century after century rolled on, scientific men took up the idea, and some among them began to think that the day was not far distant when a reform in the weights and measures of their own country would be possible. This idea gradually gained ground, and as nothing could be alleged against it, since all were at least tacitly agreed that the same standards of weights and measures should be used by one nation, schemes began to be propounded and even elaborated. Others going further began to think of a system which might find general acceptance, and ultimately become universally adopted. This was chiefly the case among French men of science, who, at the same time, realised the fact that if a system of weights and measures is to have any chance of being generally employed, it must be devised and constructed in such a manner that its measures shall not be peculiar to any particular race or nation, so that jealousy may not prevent its general adoption.

In short, it was long ago understood that if a system of weights and measures is to become universal its weights and measures must be derived from one single unit, and that unit must itself be derived from something common to the whole world. The earth itself being the common inheritance of man, it was selected as the one thing from which a standard of measurement should be derived, and the standard of length being the simplest, and most commonly used, many were the attempts made to derive a standard of length from the dimensions of the earth.

Such measurements were undertaken at various periods, even in ancient times. Among the more accurate measurements of more recent date must be mentioned those made by Fernel, Snell, and Norwood. The first, a Frenchman, roughly measured, in 1550, an arc of the meridian between Paris and Amiens by means of the wheels of a carriage registering the number of turns. The second, a Dutchman, who died in 1626, measured the distance between Mechlin and Alkmaar by means of a series of triangles; while the third, an Englishman, performed a similar calculation, in 1635,

between London and York by availing himself of the means employed by his two predecessors.

So far, however, no accurate measurement of the earth had been obtained, for the means employed had been far too rough. It was not until the astronomer Picard was ordered by Louis XIV. to measure the length of an arc of the meridian between Amiens and Malvoisine that any accurate measurement of the earth was made. It was this same astronomer who also proposed to adopt as a standard of linear measure the length of the pendulum beating the second at the latitude of Paris. The various measurements necessitated by these projects gave rise to disputes among the scientific men of the day about the value of Newton's statement that the earth is slightly flattened at the poles. In order to settle that question various operations and measurements were undertaken, which, though extremely interesting, cannot be detailed here. However, all those experiments and calculations went to prove the truth of Newton's statement, which was finally adopted as an indisputable fact. As yet nothing had been practically done towards the introduction of a better system of weights and measures. However, the days of the French Revolution were approaching fast, and this upheaval, which changed so many things, was also to effect a revolution in the weights and measures of France. Indeed, less than a year after the fall of the Bastille, the National Assembly of France, by a decree of May 8th, 1790, requested Louis XVI.—a request then tantamount to an order—to concert with the King of England so that a society of scientific men from the two countries might determine, at latitude 45°, or at any other that might be subsequently adopted, the length of the pendulum beating the second, in order that this length might be adopted as the linear measure from which all the other standards should be derived.

Unfortunately for the scheme, the political events which soon followed prevented its realisation, and a French commission alone was entrusted with the work. It was also decided, after mature consideration, that as it was desirable that the new standard should not be special to any one nation or place, the length of the pendulum which beats the second should be abandoned, since this length varies with the various latitudes, and the selection of a particular latitude would

at once create jealousies. In the place of this proposed standard another was adopted which belongs to no people and no country, or rather which is common to all of them, and that is the length of a meridian between the pole and the equator, divided by ten millions.

Such was the final resolution presented to the National Assembly of France on March 19th, 1791, by the Scientific Commission. A fews days later this resolution was adopted.

The work of the Commission had been much more thorough than is generally known or even supposed, for it went far beyond the mere choosing of the standard which should serve as a basis for all the other weights and measures. In short, the work undertaken by its members left nothing to be desired. The whole system was elaborated, the weights and measures were invented and arranged; the Metric System was entirely created, the only thing remaining to be done being the accurate determination of the standard of linear measure. As this could not be effected at a moment's notice, it was subsequently decided that a temporary metre should be adopted, and that new weights and measures, framed according to the new system, should be used throughout France.

In the meantime Delambre and Méchain, two very distinguished and well-known mathematicians, were engaged in measuring, as accurately as possible, an arc of the earth's meridian from which the total length of the whole distance from the pole to the equator could be arrived at. The arc selected extended from Dunkirk, in the North of France, to Barcelona, on the east coast of Spain. This task occupied no less than seven years, during which, owing to the disturbed state of Europe, the two mathematicians were more than once in danger of their lives. At length, their labours being completed, they returned to Paris and presented their report.

A "Commission of Weights and Measures," composed of twenty-two members chosen from various countries in Europe, then undertook the final work based on the calculations of Delambre and Méchain. The greatest care was bestowed on the work, and, so as to leave nothing to chance, the calculations of the two mathematicians were subjected to the most scrupulous revision, and to make matters doubly

sure, their calculations were performed anew and by different methods. The flattening of the earth at the poles was also taken into account, and finally the distance from the pole to the equator was obtained.

It would hardly be fair not to mention, in connection with this work, the name of Lenoir, who from the very outset manufactured all the instruments necessary to the carrying out of the preliminary operations, and who subsequently made the two standards of linear measures now preserved in the Palais des Archives in Paris. Neither can we omit to couple with his name that of Fortin, the well-known inventor of the famous barometer which bears his name, and who made some of the other standard measures.

Such was the perfection of the instruments used by the members of the Commission, that one of them, Lefèvre-Gineau, declared that he had been able to determine the volume of the cylinder which served to make the unit of weight to the seventeen-hundredth part of a millimetre, that is, to about the fifty-thousandth part of an inch.

Such is briefly the history of the origin of a system which, in spite of the opposition it has met with—chiefly because it destroys old usages and customs—has now been adopted by many nations who have recognised its value and appreciated its beautiful simplicity.

The Metric System of weights and measures was made compulsory in France from the 2nd November, 1802, but as many opposed its adoption it was subsequently, and unwisely, decreed that the old measures, though metrically altered, should still be used. Unwisely, I have said, because if the metric measures had been at once made compulsory, people would very quickly have got used to them; and besides, as they are most easily learnt, the grumblers would soon have been reconciled to the new system, since no one having used the two kinds of measures could have hesitated for a single moment to pronounce in favour of the metric standards.

However, this system of compromise went on until 1837, when the metric measures, pure and simple, were made compulsory. Henceforth the old measures were entirely discarded, and schoolmasters were enjoined not to teach the old measures any more. At the same time arithmetic books used in primary schools had to be altered so as no longer to

contain the old standards, but to give in their place the measures of the Metric System.

As some persons occasionally affirm that the old system is still used in France, I feel bound to give a most emphatic denial to such a wanton assertion. It is true that we still have the words *livre* and *sou*, though even these words are less and less used; but when one asks for a *livre* of anything, nothing but a half kilogramme, or 500 grammes, is meant, and it would also be written so, just as 18 *sous* would be written 0^f, 90. These words are now the only survivals of the old measures, together with a few local agrarian measures only heard of in conversation, but neither legal nor used by surveyors. The old system has indeed so thoroughly disappeared, and is now so well forgotten, that even thirty-five or forty years ago it was usual, in the higher mathematical classes of the Paris Lycées, to devote one lesson to the study of the old standards, which were given by way of showing pupils how much the new standards are superior to the old ones.

In closing this chapter I cannot help remarking that those who are most strenuous in their efforts to introduce the Metric System of weights and measures into this country are not mere faddists, who utterly and systematically ignore the claims of practical men. They are, on the contrary, very practical men, and although they are fully aware that the change from the present measures to a decimalised system would not be unattended by difficulties, they also know that those difficulties are often greatly and unnecessarily magnified, since other countries have effected the change with but little trouble. The opponents of the change should remember that the time is not yet far distant when the weights and measures of certain Continental countries were in a still more chaotic state than in England. Every country had a linear foot which differed from one place to another, whilst there were as many pounds avoirdupois as there were states in Europe. Besides the standards in general use, almost every trade had measures peculiar to itself, and the most common measures frequently differed from one province to another, and occasionally from town to town. In Germany, owing to the numerous states into which the country was divided, the chaos was greater still, indeed it might be termed the perfection of confusion.

This, however, has not prevented the Germans from introducing the Metric System into their country, and I have never yet come across a German who evinced a desire to return to the old state of things, that is, to the babel of measures formerly prevailing in his country.

It seems to me that a great commercial nation like England might take into account what has been done by her not unworthy commercial rival, Germany, and that, at any rate, English people should no longer say that a change in their system of weights and measures is an impossibility, or at least is a matter surrounded by such difficulties as to be nearly so. Surely what has been done in other countries, and in recent times too, can also be done here! To assert that it cannot be done is at once a confession of impotence, and that is hardly the construction the adversaries of a reform in that direction would like us to put upon their systematic opposition.

Besides, the question turns upon the following point: either the Metric System is better or worse than the system at present in use. If worse, then leave it alone and let us say no more about it; if, on the contrary, it is better—as I hope to prove—then let us adopt it, and do not let us retrench ourselves behind prejudices which are only prejudicial to the commercial interest of this country, nor assert that the change presents too many difficulties to be overcome by Englishmen. In any case, men of business can no longer, in their own interest, remain ignorant of the methods of the Metric System, which, to them, are of practical importance, since they are in use in almost all the countries with which they have commercial intercourse.

CHAPTER II.

ON THE ADVANTAGES AND DISADVANTAGES OF THE METRIC SYSTEM

THE simplicity and clearness of the Metric System are such that it would seem that the most cursory inspection of its principles ought to convince all but the most prejudiced persons of the immense superiority it possesses over all other existing systems. However, as many objections have been raised, and are still being systematically raised, against its introduction in these realms, it will not be amiss to show that the objections brought against the Metric System are absolutely groundless, whilst among the upholders of the system are some of the greatest scientific men of the century.

The main objection raised against the introduction of the Metric System is that, being at the same time a decimal system, it has fewer divisors than a system having twelve for its basis. As it is an undeniable fact that twelve has more divisors than ten, some have grown so enthusiastic over that sublime discovery that they would like us to adopt, at once, a system based on a duodecimal scale. They also lament the fact that most of the great nations of the present day are using the Metric System, and some among them have even asserted, and written, that "practical legislators have pronounced the number ten to be most unsuitable as a basis, especially for the purposes of retail trade." If such is really the case, it shows that those practical legislators have still a good deal to learn.

In proof of the above assertion, quoted from *Chambers's Encyclopædia*, we are told, by the same writer, that if an article quoted 1.25 franc per yard, or per pound, has to be sold by the half yard, or the half pound, the article cannot be exactly priced, and that in consequence the buyer suffers, while the

analogous price 1*s.* 3*d.* can be easily halved and quartered. Nothing can be more true, but unfortunately for the adversaries of the Metric System the very same objection can be raised against the present system of English weights and measures, provided we are sufficiently honest to take numbers that are not so easily manipulated. If, for instance, we take the commonly quoted prices, 1*s.* 5¾*d.* and 1*s.* 11¾*d.*, so dear to our drapers, neither of them being susceptible of being halved or quartered, the customer is equally cheated, and even more so than abroad, since 1*s.* 5¾*d.* and 1*s.* 11¾*d.* are practically the same as 1*s.* 6*d.* and 2*s.*, the farthing being now almost an obsolete coin. The plain fact of the matter is that in such cases a great deal is made out of nothing.

Others have also discovered that decimal numbers do not lend themselves to mental calculations. Why not? Since any arithmetical operation performed in decimal numbers can be performed with as much ease as in the case of ordinary numbers, this objection falls at once to the ground. Such an oft-made objection can only arise from prejudice or ignorance, the latter being undoubtedly the case when it is affirmed, as was recently done in the *Times*, that "decimals know of no halves and no quarters." Only the most ignorant person can make such an assertion. If decimals know of no halves and no quarters, then what are 0·5 and 0·25?* Of course persons who wish to use the decimal system of weights and measures should lose no time in becoming acquainted with the working of decimals. Any elementary arithmetic books—to say nothing of this one—will teach them how to handle them, and if these conscientious objectors will take the trouble to devote a few hours to decimal fractions, they will soon discover that it is very much easier to work with them than with vulgar fractions, and they will also understand that decimal fractions have halves and quarters.

On the other hand, decimal fractions are no longer entirely a matter of choice. With the advance of mechanical industry their use has become imperative, since in many kinds of work

* Throughout this book a 0 will be used before the decimal point when there is no whole number. It is a better plan than writing ·5 and ·25, for if the dot is not very clear those fractions may be taken as whole numbers. The 0 in front obviates this; and besides, it is in use everywhere on the Continent, and the Civil Service Commissioners and the instructors on board H.M.S. *Britannia* follow the same rule.

the hundredth, or even the thousandth part of an inch has to be taken into account. Electrical engineers are also among those who employ nothing but decimals, though electricity may be said to be only in its infancy.

In a report of Consul Warburton (*Daily Telegraph*, April 24th, 1899) occurs this characteristic passage:—

"Travellers may," he writes, "work up a demand for some particular article, but what happens is this, that as soon as it becomes worth anything a French manufacturer is sure to find out that the average 20 per cent. which carriage and duty add to the cost, is a sufficient inducement to make it at home; the buyers, from a natural feeling of patriotism, encourage him, and he finally **arrives at such a pitch of perfection, with exactitude of decimal sizes,** . . . that no one cares to buy the foreign article."

I will now quote some of the more eminent authorities in favour of the use of a decimal system. Mr. Jefferson, Secretary of State, in a Report on Money, Weights, and Measures, presented as early as 1790, testified to the value of the decimal system in coins and accountancy in the United States of America.

"The experiment made by Congress in 1786," said he, "by declaring that there should be one currency of accounts and payments through the United States, and that its parts and multiples should be in a decimal ratio, has obtained such general approbation, both at home and abroad, that nothing seems wanting but the actual coinage to banish the discordant pounds, shillings, pence, and farthings of the different states, and to establish in their stead the new denominations."

Among other warm advocates of the use of the decimal system was also Mr. Thomson Hankey, one of the former Governors of the Bank of England. His testimony is doubly valuable since, whilst advocating the use of a decimal system, he emphatically condemned the clumsiness of the method still in use. It must also be remembered that Mr. Hankey was not a faddist, but a man of business who spoke to a great extent from experience. His testimony, or rather a part of it, given before a Parliamentary Committee in 1853, is as follows:—

"During the time I held the office of Governor of the Bank of England my attention was particularly called to the subject, in consequence of what appeared to me to be the extremely

complicated system of keeping accounts with respect to all transactions in the purchase or sale of bullion at the Bank of England. I found, on examining into the system, or mode of keeping such accounts, or of making such calculations, that there were three elements which entered into the consideration; the first was the weight, which was calculated in troy pounds and ounces, of which there are twelve to the pound; pennyweights, of which there are twenty to the ounce; and grains, of which there are twenty-four to the pennyweight. The second element was the quality of the gold, which was subdivided by carats, a carat meaning the twenty-fourth part of any quality of gold; the carat was again subdivided into eight. The third element was pounds, shillings, pence, and farthings. A more complicated system, and one more fraught with incidents to error, can hardly be conceived; it requires, in fact, an extremely expert calculator to make even any ordinary calculations of the kind; so much so that I do not believe that any merchants, or ordinary dealers, ever make the calculations themselves; they employ brokers, who transact the business for them, and these brokers use a voluminous series of tables by which they arrive at the results of the calculations. This appeared to me to be so extremely inconvenient a system, and so extremely difficult for myself to learn, that I was anxious to see whether I could not, for my own private purposes, make calculations by a system of decimal tables, and I found that by using the decimal ounce, and discarding altogether the pound troy, a very much more simple mode of calculation could be arrived at; and it was after much consideration on the subject that the Bank of England determined to take advantage of the anomalous state of the law respecting the pound troy, and respecting troy weights generally, to discard altogether the use, from all other calculations, of the pound troy."

Then Mr. Thomson Hankey went on detailing the scheme, and finally, in order to illustrate his evidence, Mr. William Miller was called as a witness before the Parliamentary Committee, to whom he presented the following examples of calculations in which are contrasted the cumbrous operations of the non-decimal system with the wonderful simplicity of the decimal method.

I shall now reproduce those examples, for they will indeed speak for themselves, especially the third one, which shows the calculations if we had a decimal coinage, and if the standard gold, which in England is $\frac{11}{12}$, were the same as the standard gold of many other countries, such as France, Holland, the United States, etc., that is to say $\frac{9}{10}$.

Example I.—What is the value of a bar of gold weighing 79 lbs. 7 oz. 17 dwts. 12 grs., reported by the assayer to be 5 carats 3 grains and $\frac{7}{8}$ worse,* and what is the weight in standard?

This is the detail of the work:—

```
    carats      cts.   cts.  grs.       lbs.  oz.  dwts.  grs.
As   22    :    22    - 5    3 7/8  ::   79    7    17     12
      4         5 3 7/8                  12
    ----       -------                 ----
     88        16 0 1/8                 955
      8          4                       20
    ----       ----                   -----
    704         64                    19117
                 8                       24
               ----                   -----
               513                    76480
                                     38234
                                    -------
                                     458820
                                        513
                                   --------
                                    1376460
                                    458820
                                  2294100
                                 ----------
                           704 ) 235374660 ( 334339
                                 2112
                                 ----
                                  2417
                                  2112
                                  ----
                                   3054
                                   2816
                                   ----
                                    2386
                                    2112
                                    ----
                                     2746
                                     2112
                                     ----
                                      6340
                                      6336
                                      ----
                                         4
```

This so far only gives us the standard weight in grains.

* Assayers suppose gold to contain 24 carats, the carat 4 parts called grains, and which have nothing to do with the weight of a grain, and each grain 8 parts. They define the quality of gold by degrees, each of which is the 768th part of the whole, and in their report they compare the gold they have assayed not to pure gold, but to standard gold of 22 carats, and they speak of gold as "better" or "worse" than standard.

This must be reduced to pounds, ounces, pennyweights, and grains.

```
    ( 3) 334339 grains
 24 {  ×
    ( 8) 111446 : 1
    2,0) 1393,0 : 19
     12)  696 : 10 : 19
     lbs.  58 : 0 : 10 : 19
```

which is the weight in standard gold.

We have now to find the value at the Mint price of £3 17*s.* 10½*d.* per ounce.

```
      oz.       grains         £    s.   d.
As    1    :    334339   ::    3    17   10½
     20                       20
     --                       --
     20                       77
     24                       12
     --                      ---
     80                      934
    40                         4
    ---                     ----
    480                     3738
                          334339
                          ------
                           33642
                          11214
                         11214
                        14952
                       11214
                      11214
                      ----------
               480) 1249759182 ( 2603664
                     960
                     ----
                     2897
                     2880
                     -----
                        1759
                        1440
                        -----
                         3191
                         2880
                         -----
                          3118
                          2880
                          -----
                           2382
                           1920
                           ----
                             46
```

```
   Farthings.
 4) 2603664
12)  650916
2,0)  5424,0
   £2712  3s.  0d. = Ans.
```

Example II.—The same question with the weight expressed decimally :—

What is the value of a bar of gold weighing 955·875 ounces at 5 carats $3\frac{7}{8}$ grains worse?

```
      carats        cts.    cts.  grs.        ounces.
As     22     :     22     - 5    3⅞    ::    955·875
        4            5 3⅞                         513
      ---          -----                   ----------
       88          16 0⅛                      2867625
        8             4                       955875
      ---           ---                      4779375
      704            64                    -----------
                      8        704) 490363·875 (696539 419/704 ounces
                    ---             4224                  in standard
                    513             ----
                                     6796
                                     6336
                                     ----
                                      4603
                                      4224
                                      ----
                                       3798
                                       3520
                                       ----
                                        2787
                                        2112
                                        ----
                                         6755
                                         6336
                                         ----
                                          419
```

```
Value at £3 17s. 10½d.
                  696·540
                        3
                 --------
15s. 0d. | 1/4  | 2089·620
 2s. 6d. | 1/6  |  522·405
     3d. | 1/10 |   87·067
    1½d. | 1/2  |    8·706
                     4·353
                 --------
               £2712·151
                      20
                 --------
                   3·020
```

Ans. £2712 3*s.* 0*d.*

Example III.—The same example worked entirely with decimals and supposing standard gold to be $\frac{9}{10}$, which would make its Mint price £3 16*s.* 5½*d.*, or, in decimals, £3·823. The question would in this case then be asked as follows:—

What would a bar of gold, weighing 955·875 oz, reported to be 667·96 oz. fine, yield in ounces standard, and what would be its value?*

$$
\begin{array}{rr}
\text{As } 900 : 667{\cdot}96 :: & 955875 \\
 & 69766 \\
\hline
 & 5735250 \\
 & 573525 \\
 & 66910 \\
 & 8602 \\
 & 573 \\
\hline
900) & 6384860 \\
\hline
 & 709430 \text{ ounces standard} \\
\text{At price} & 3283 \\
\hline
 & 2128290 \\
 & 567544 \\
 & 14188 \\
 & 2128 \\
\hline
 & £2712{\cdot}150 = \text{Ans.}
\end{array}
$$

Commentaries are unnecessary.

The late Professor Airy's testimony before the same Parliamentary Committee is equally invaluable. In answer to the question whether the decimal system of coinage would not give great facilities in the way of calculating discount and interest, this is what he replied:—

"Every calculation of that sort would be made very much easier. But I may mention that even calculations of the smallest kind would be very much easier; for instance, a few days ago I was looking at a gas stove, and I inquired how much it burned. I was told seven cubic feet in an hour. My gas costs me four

* In order to avoid an unnecessary number of decimal figures, the shortened form of multiplication should be used (see page 36).

shillings per 1,000 feet. How am I to calculate the hourly cost? I found the easiest way was to turn it into decimals and to do it by mils.* Four shillings gives 200 mils. I multiply that by seven feet, and the result is one and four-tenths mils per hour. I am not a very bad calculator, and yet it would take me several times as long to do it by pence and farthings."

Being asked if he could mention other instances in which the change to a decimal system would be advantageous, the Professor stated at once that the great centesimal change proposed in France at the end of the last century had been of great advantage to him in astronomical calculations; and he further added that "it would be the means of a very great saving of labour to contractors, builders, and others."

Another valuable testimony was that of Professor de Morgan, who thus summed up some of the advantages of a decimal system :—

"1. All computations would be performed by the same rules as in the arithmetic of whole numbers.

"2. An extended multiplication table would be a better interest table than any which has yet been constructed.

"3. The application of logarithms would be materially facilitated. and would become universal, as also that of the sliding rule.

"4. The number of good commercial computers would soon be many times greater than at present.

"5. All decimal tables, as those of compound interest, etc., would be popular tables, instead of being mathematical mysteries.

"6. The old coinage would be reduced to the new by a simple rule.

"7. When the decimal coinage came to be completely established, the introduction of a decimal system of weights and measures would be very much facilitated, and its advantages would be seen."

To these Professor de Morgan further added :—

"I am of opinion that considerably more than half of the trouble of money calculations would be saved (by the adoption of a decimal system). An advantage connected with that would be that the school arithmetic would make boys ready in business, which they are not now, for with their imperfect learning of the decimal system, and their halting between two systems, most men

* The *mil* would, in the new coinage, be the one-thousandth part of £1 sterling (see page 75).

of business will tell you that boys do not come from school very well prepared in business arithmetic. I have heard of a banker who, when asked what a boy who was to enter his bank should do at school to prepare himself in arithmetic, answered, 'For goodness' sake let him do nothing! Don't trouble yourself about him, and when he comes to us we will teach him what he has to do. If he can add pounds, shillings, and pence, that is the only thing we can hope for from school teaching.'"

And again:—

"I think that, taking all the schools in the country, commercial as well as classical, and considering in how many of them reading, writing, and arithmetic form the great mass of what is taught, I am not putting it too high when I say that arithmetic forms the fifth part, in time, of all the primary education given in the country, that is, 20 per cent. of all the primary education. I think that is under the mark. I am sure I am putting the evils of the present system rather low when I say that they cause one-fourth of that time to be uselessly employed, that is to say, one-twentieth part of all the time spent in primary education in this country I consider to be thrown away by the present system of coinage, weights, and measures."

Here I must needs stop—not because I cannot quote other authorities, but because to mention only half of those I have at hand would swell the bulk of this book beyond reasonable limits. All the witnesses heard before the Parliamentary Committee alluded to, *without a single exception*, agreed on the advantages of a decimal system of coinage, weights, and measures, and all concurred in the desirability of a change in the present system. It must not be forgotten that the witnesses heard belonged to all classes, that the Committee was representative of various interests, and that by the side of business men, bankers, accountants, were some of the most eminent men of science of the day, such as Sir John Herschel, Professor Airy, and Professor de Morgan. Among the advocates of a decimal system of weights and measures were also several members of Parliament and statesmen, and the then Governor of Hong Kong, Sir John Bowring, who, not long after the Parliamentary inquiry, wrote a work entitled *The Decimal System*,* a work which deserves to be better known than it is.

* *The Decimal System in Numbers, Coins, and Accounts.* London: Nathaniel Cooke, Milford House, Strand. 1854.

However, as this is not all that can be said in favour of a decimal system, we will now mention a few special points.

Instead of a system of weights and measures which seems to have originated out of mere fancy, and which, as all will admit, is complexity itself, we have in the Metric System an order, a method, a clearness, and a simplicity that can never be more than equalled by any other system. Besides these advantages we have others equally great. Our mind, for instance, is no longer burdened with the learning of cumbrous and meaningless tables. In the Metric System there is one specific word for each unit, and this word exclusively designates the one thing it is meant to represent; and from this one word, to which can be prefixed particles which are the same for all units, every multiple and sub-multiple can be expressed, that is, everything can be measured or gauged. This means that, instead of an endless nomenclature, **thirteen** words, and no more, are sufficient to express every kind of measure.

Instead of compound rules, all the operations of arithmetic are reduced to simple ones. Practice is unnecessary, and if we have to deal with weight, be it the weight of a hogshead of sugar or that of an ingot of gold, we are no longer compelled to pause to think whether we are dealing with avoirdupois weight or with troy weight, and whether we have to do with a standard of weight which, though heavier, as is the pound avoirdupois, yet contains ounces which are lighter than those of troy weight.

To those advantages must be added still another one almost as great, and that is the complete decimalisation of the Metric System. Decimals are indeed the most convenient fractions to use, simply because they are a mere continuation of the integral part; that is to say, that just as we have units, tens, hundreds, thousands, before the decimal point, we have tenths, hundredths, thousandths, after it. This fact offers great facilities for reckoning, and as the Metric System is also decimalised, it must of necessity offer facilities for calculation greater than in any other system, not excepting the duodecimal system, advocated by many, who forget that a duodecimal system is not yet in existence, and that before it could be used, or even practically tried, it must first be invented.

It is perfectly true, as the few advocates of the duodecimal

system constantly remind us, that twelve is divisible by 2, 3, 4, and 6. Yet as our notation is decimal and not duodecimal—this fact is usually disregarded—this slight, very slight, advantage is practically useless. If we had a duodecimal system of weights and measures we should not be much better off than we are now, unless we had at the same time a duodenary scale of notation; that is, instead of the nine digits and zero which we now use, we should require another digit to express eleven. Besides this, as 1 followed by a zero would no longer, in the duodenary scale, represent 10, but 12, we should also want a new digit for 10. Now if we use *t* for ten and *e* for eleven, the scale of notation would read as follows in the duodenary scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, *t*, *e*, 10, 11, the latter numbers 10 and 11 standing respectively for 12 and 13, since the digits written consecutively would increase twelvefold as we move towards the left, so that 21, in the duodenary scale, would represent 25. I am quite aware that for some years past the duodecimal system has been advocated by no less a person than Mr. Herbert Spencer, who has told us, in the columns of the *Times*, that instead of adopting the Metric System we should wait until a duodecimal system can be introduced. Now with all due deference to Mr. Spencer, I strongly protest against such an assertion. To Mr. Spencer and his school the change from the present complex system may not seem desirable, because those who write on evolution are very seldom troubled with arithmetic, but to the business man and the teacher it is otherwise. Whatever the evolutionists of England may think, they cannot get away from the hard fact that mankind has been in the habit of counting by tens from the most remote period. This may have been a mistake, but then why did nature provide us with ten fingers instead of twelve? It is possible that, according to the laws of evolution, mankind may some day find itself provided with twelve fingers, and that our remote descendants may then get into the way of counting by twelves, and prefer a duodenary system. Be that as it may, we are still addicted to counting by tens, and we shall probably do so for many centuries to come. After that time the men of twenty or thirty centuries hence may divide the metre into 144 parts instead of 100 centimetres, and they may then readily understand that 21 stands for 25, and 100 for

144. As for the present time, few are those who realise that 100 can stand for twelve times twelve, and fewer are those who care to know why it should do so. Before we say any more on the subject, it will not be amiss to see what this wonderful duodecimal system can do for us. Although not yet in existence, it is partly found in our weights and measures, in the division of feet into inches, and of inches into twelves, and as such is used by engineers, builders, painters, and some others in measuring their work.

We will now see, by means of an example, whether it is better than the Metric System would be.

Let us suppose, for instance, that we wish to find the area of 3 yds. 1 ft. 4′ 5″ by 2 yds. 1 ft. 8′ 6″. The operation performed according to the duodecimal system would stand as follows:—

10 ft.	4′	5″		
7	8	6		
72	6	11		
6	10	11	4‴	
	5	2	2	6⁗
79	11	0	6‴	6⁗

Now suppose we have to find the area of 4·325 metres by 3·215 metres, the operation will at once be reduced to an ordinary multiplication, thus:—

```
 4·325
  5123
------
 12975
   865
    43
    21
------
13·904
```

The great advantages of the decimal system are conspicuous in this case. In the first place the operation is shorter, but better still it is *only* a multiplication, whilst in the case of the duodecimal system we have to perform not only a multiplication, but also a division and a subtraction at every step. Thus for the first line we have to say, mentally, 7 times 5 are 35, which contains twice twelve plus 11. We write 11″

and carry 2. Then 7 times 4 are 28, and 2 are 30, which contains twice twelve plus 6 over, which we write down under the inches; and, finally, 7 times 10 are 70, plus 2 over, are 72. Then, further, if we had to find the money value, as is probably the case, the operation which in the first case is rather complicated would, in the other instance, be reduced to an ordinary multiplication of decimals and nothing more.

It is also evident that a mistake is more likely to be made when we have to deal with feet, inches, pounds, shillings, and pence than when performing two ordinary multiplications of decimals, which can further be checked most easily by casting out the nines.

If, as is the case in engineering, very great accuracy is required, decimals are again to be preferred, and are indeed preferred by engineers.

In other cases, whenever English weights and measures are used, the only way of working is by reduction or practice. There again the superiority of decimals will be best seen by two examples.

Suppose we were required to find the price of 17 cwt. 3 qrs. 21 lbs. at £1 2*s.* 3*d.* per cwt., the operation would stand as follows:—

		£	*s.*	*d.*	
		1	2	3	
				17	
2 qrs.	$\frac{1}{2}$	18	18	3	= 17 cwt.
1 qr.	$\frac{1}{2}$		11	$1\frac{1}{2}$	= 2 qrs.
14 lbs.	$\frac{1}{2}$		5	$6\frac{3}{4}$	= 1 qr.
7 "	$\frac{1}{2}$		2	$9\frac{1}{4}$	= 14 lbs.
			1	$4\frac{1}{2}$	= 7 "
		£19	19	1	

The corresponding sum would be worked thus in the Metric System:—

Find the value of 879 kilograms at 27·45 francs per 100 kilograms.

```
   27·45
     879
  ------
   24705
  19215
 21960
 -------
 241·2855
```

Two decimals in the multiplicand will have to be taken into account, and to divide further by 100, the point will be removed two more places towards the left, thus making the result in francs and centimes 241·29 fr., or rather, as is done in business, 241·30 fr.

I think the most prejudiced person will admit that this last sum is simpler than the practice sum given just before it, and that it is not fraught with the same sources of error. Little more need be said on the subject, yet as some most extraordinary objections have been published in the *Times*, there are a few of them that cannot be overlooked, were it only to show that those who object to the introduction of the Metric System are oftener guided by prejudice than by sound common sense, or real knowledge.

In the number of the *Times* for April 4th, 1899, a writer asserts that "the Metric System does not fit our time measures, natural or artificial. We have twelve full moons in a year, and cannot make the months agree with them." Now when an objector can write such startling things, it is easy to understand that he must find the Metric System a very difficult one to learn. I had always thought there could be thirteen full moons in a year, but evidently it is never so, and the advocates of the duodecimal system probably mean to regulate the moon in a better manner, and by a process of evolution they will arrange the full moons duodecimally. Many among the objectors do not understand that there is no need of decimalising everything. Even in France, where the decimal system was long ago carried to a greater length than in most other countries, there are several things which have not been decimalised. The divisions of time, and those of the circumference, are examples in support. I am aware that it is occasionally affirmed that the French have discarded the "degrees" for "grades," but unfortunately it is not so. I say unfortunately, because it is a great pity that the proposed decimalisation of the degrees of the circumference was not adhered to, since it is assuredly as convenient to divide the quadrant into 100 parts, themselves subdivided into hundreds, as to have 90° with minutes and seconds. One very great advantage of this decimalisation would have been to enable us to write 60° 35′ 17″ in this simple way, 60·3517 grades.

If this division was not adopted, it was not, as some complacently imagine, because it was inferior to the old one, but simply because those who were the owners of mathematical tables published on the old system threw every obstacle in the way, as the adoption of the new method would have rendered their property well-nigh useless. Moreover, as it was a question in which the public at large felt no interest, the advocates of the decimal notation were unable to effect the reform for want of general support.

Enough has now been said to show that the Metric System can well hold its own against any other, and though I am not presumptuous enough to think that the systematic objectors will be convinced, yet I feel sure that those who are less narrow minded, and who will weigh the pros and cons of the case, will readily admit that if the Metric System is not perfect it is at any rate as near perfection as it is possible for any human invention to be, and that, to say the least of it, it is far superior to any system hitherto devised.

Those who advocate the adoption of the Metric System are not mere faddists. I have already shown that it has had the support of some of the most eminent men of science of England, members of Parliament, bankers, business men, and consuls. Those who look around them, and take the trouble to see what is going on, know, as well as I do, that many foreign business men prefer to transact business where a system of weights and measures similar to their own is in use. Now England can no more force her weights and measures on other nations of the Continent than she can force her language upon them; and just as those foreign merchants who do not speak English prefer to deal with people who understand their vernacular, so do they also prefer dealing with firms keeping their accounts in a way they are familiar with.

English men of business have at last realised that they have lost a good deal of trade through their inability to speak foreign languages; it is to be hoped that they will soon realise that they are also losers by using such a cumbrous system of weights and measures as the one they now employ.

My conviction is, and it is based on inquiry, that they probably lose more business through their weights and measures than through their inability to speak foreign lan-

guages, and for the simple reason that while many foreigners can speak English, few are familiar with the methods of English reckoning. In some cases it has been said to me that English invoices are so incomprehensible that they must be accepted without the least inspection—a method of doing business which certainly is not satisfactory, and which must often drive foreigners to transfer their orders to other markets. In a foreign firm, doing a good deal of business with England, I know for certain that a special staff has to be kept on purpose to examine English invoices and accounts. It is probable that the extra expense thus entailed will last only as long as the goods must be procured in England. The day the goods can be obtained elsewhere the English firms will be given up.

As for the difficulty of learning the new system, it has been much exaggerated. I am positive that there is not a clerk in the great commercial centres of this country who could not make himself thoroughly proficient in the Metric System during the spare evening hours of a month or two. As for those who are thoroughly at home with decimals, the new system could certainly be thoroughly mastered within a few hours.

Lastly, and even at the risk of being told that I am repeating what has already been stated, I cannot close this chapter without singling out a few facts which prove that the Metric System is fast becoming the universal system of weights and measures, and that before long its adoption throughout the British Empire will no longer be a matter of choice, but a dire necessity. The Metric System has now been adopted by all the different Governments of Europe, Great Britain and Russia excepted, and as there are indications that it will soon be used in Russia, Great Britain will then be the only country of importance in Europe to use an antiquated, cumbrous, unmethodical, and purely fantastic system of weights and measures.

This clumsy and almost antediluvian system will, then, soon be the exclusive monopoly of the English nation, that is, of about 113 millions of people, while the Metric System now provides 329 millions of other civilised beings with weights and measures.

The fact that the British Parliament made it legal, in 1898,

for anyone in the United Kingdom to use the weights and measures of the Metric System, proves that its value has now been fully recognised by the Legislature of this country. However, so long as the old measures are not altogether tabooed, there is but little chance of a business man using the metric weights and measures, since this would mean the keeping of a double set of accounts. Lastly, we should bear in mind that all the British consuls abroad are constantly urging, in the reports they send home, the immediate adoption of the Metric System; and, as they are in the best position to form a correct opinion on the subject, their recommendation ought to be heeded, for they have naturally at heart the interests of British commerce.

CHAPTER III.

THE WORKING OF DECIMALS

BEFORE entering upon the study of the Metric System, it will not be amiss to devote a short chapter to the working of decimals, with which people are by no means as familiar as they should be.

We shall only say what is essential, leaving out a great deal that is never used—simply because it is useless—and we will show that decimals are much more easily handled than vulgar fractions.

Decimal fractions are portions of the unity which are ten, a hundred, or a thousand times smaller than the unit; and their great beauty is that they are a continuation of the integral part, and that just as we have units, tens, hundreds, thousands, before the decimal point, we have tenths, hundredths, thousandths, after it. To make this quite clear, let us suppose we have to deal with number 7.

If 7 be written by itself—7, it stands for 7 units. If the same number be followed by 0, it then stands for 70; if by 00, for 700; and so on. That is, as 7 moves one place towards the left it increases tenfold; for two places, 10×10, or a hundredfold; and for three places, $10 \times 10 \times 10$, or a thousandfold; and so forth. So that 777 is really the same as $700 + 70 + 7$. Now, if this same number, instead of being moved towards the left of the units, is moved towards the right of them, it will become ten times smaller for each place. So that 7 written on the right of 7 units will be equal to the tenth of it, or $\frac{7}{10}$; if it is removed two places to the right, it will be equal to the tenth part of $\frac{7}{10}$, or $\frac{7}{10 \times 10} = \frac{7}{100}$; that is, it will then be the hundredth part of what it was when occupying the units' place.

To show where the units end, and where the decimal part begins, a point is placed after the units and near the top of the figure. Thus:—

22·2 means:—22 units and 2 tenths.*

Decimals then can be written in the same manner as whole numbers, if we only bear in mind that whilst **tens** are on the left of the units, **tenths** are on the right of them, and so on for **hundreds** and **hundredths**, and **thousands** and **thousandths.**

The following table will show this quite clearly:—

millions.	hundreds of thousands.	tens of thousands.	thousands.	hundreds.	tens.	**Units.**	tenths.	hundredths	thousandths.	tens of thousandths.	hundreds of thousandths.	millionths.
6th	5th	4th	3rd	2nd	1st		1st	2nd	3rd	4th	5th	6th
Whole numbers.							**Decimals.**					

Now suppose we are asked to read the following: 27·123.

In England the rule is simple enough. The whole number is read first in the ordinary way, then the word "decimal" comes, and the numbers representing the decimal part are also read like an ordinary number. In the present instance 27·123 would be read: "Twenty-seven, decimal one hundred and twenty-three."

Though this answers well enough, one should be able to give the decimal part its proper name, especially so as nothing can be easier.

This naming of the decimal part is taught in some schools in England, and is universally so abroad. To read a decimal thus is very simple, if we but remember that the unit,

* It may also be noted that, in many foreign countries, a comma is used instead of a point.

followed by as many noughts as there are decimal places, represents what, in the case of vulgar fractions, would be the denominator; *e.g.*:—

$0{\cdot}1 = \frac{1}{10}$ or one tenth.
$0{\cdot}01 = \frac{1}{100}$ or one hundredth.
$0{\cdot}21 = \frac{21}{100}$ or twenty-one hundredths, and
$22{\cdot}271 = 22$ units and $\frac{271}{1000}$ or 271 thousandths.

If the decimal point is moved one place towards the **right** the tenths will then have taken the place of the units; that is, they will have been multiplied by 10, and as each part of the number has been thus multiplied the whole number will have been multiplied by 10. If the decimal point had been moved two places to the right the number would have been multiplied by 100; and if three places, by 1000. Hence to multiply a decimal number by 10, 100, 1000, and so on, move the decimal point one, two, three, or more places towards the **right.**

If the decimal point has to be removed one or more places beyond the last figures noughts must be added; *e.g.*:—

Multiply $59{\cdot}32$ by $10 = 593{\cdot}2$.
$59{\cdot}32$ „ $100 = 5932$.
$59{\cdot}32$ „ $1000 = 59320$.

It will easily be understood that if the decimal point is moved towards the **left** the reverse of what has just been stated will take place, since the units will then occupy the place of the tenths, and therefore be ten times smaller, etc. Hence to divide a decimal number by 10, 100, 1000, etc., move the decimal point one, two, three, or more places towards the **left,** and if there are not enough figures put one nought for each place; *e.g.*:—

Divide $59{\cdot}32$ by $10 = 5{\cdot}932$.
„ $59{\cdot}32$ „ $100 = 0{\cdot}5932$.
„ $59{\cdot}32$ „ $1000 = 0{\cdot}05932$.

We must note here that noughts written on the **right** of a decimal fraction do not alter its value. Thus:—

$$2{\cdot}5 = 2{\cdot}50 = 2{\cdot}500 = 2{\cdot}500000.$$

The reason of this is obvious, since in $2{\cdot}50$, although we have ten times more parts than in $2{\cdot}5$, each part is ten times smaller, hence the value of the fraction is still the same.

If what precedes has been thoroughly understood and mastered, the usual operations of arithmetic with decimals will not present the slightest difficulty.

ADDITION

The addition of decimals is performed like that of ordinary numbers, except that a decimal point is placed in the total. To place this decimal point, count the number which has the most decimals in the proposed addition, and if that number be 3, or 4, or 5, place the decimal point 3, or 4, or 5 places from the right of the total. Take care to write the tenths under the tenths, the hundredths under the hundredths, and so on.

An example will make this clear.

Add together: $178{\cdot}321 + 6{\cdot}02456 + 0{\cdot}73 + 1234{\cdot}789 + 37893{\cdot}47$.

$$\begin{array}{lr} & 178{\cdot}321 \\ & 6{\cdot}02456 \\ & 0{\cdot}73 \\ & 1234{\cdot}789 \\ & 37893{\cdot}47 \\ \hline \text{Total} & 39313{\cdot}33456 \end{array}$$

The greatest number of decimals (5) being in the second line (6·02456), five decimal places will be marked off in the total.

In passing from the column on the right of the decimal point to the one on the left of it, no notice whatever is taken of the decimal point, but the addition is performed as in the case of whole numbers.

SUBTRACTION

The subtraction of decimals is performed as in the case of ordinary numbers, except that if the number of decimals is not the same in both numbers, it is well to equalise them by adding noughts. The number of decimals to be marked off in the difference will be as in the case of addition.

Example.—From 175·27 subtract 98·314.

$$\begin{array}{r} 175{\cdot}270 \\ 98{\cdot}314 \\ \hline 76{\cdot}956 \end{array}$$

If decimals have to be taken from a whole number we may proceed in the same manner, and add as many noughts to the whole number as there are decimals in the smaller number.

Example.—From 21 subtract 0·213456.

$$\begin{array}{r} 21{\cdot}000000 \\ 0{\cdot}213456 \\ \hline 20{\cdot}786544 \end{array}$$

After a little practice it will be found that these noughts need not be written at all, and also that in subtractions similar to the last one it is more convenient to subtract the first figure on the right from 10 and all the other decimals from 9 without carrying 1 as usual, except after the decimal point has been reached. This is especially convenient when the number of decimals is large.

MULTIPLICATION

To multiply decimals together, discard the decimal point in both multiplicand and multiplier, then multiply in the ordinary way, and mark off in the product, counting from the right, as many decimals as there are decimal places in both multiplicand and multiplier.

Example.—Multiply 327·273 by 5·003.

$$\begin{array}{r} 327{\cdot}273 \\ 5{\cdot}003 \\ \hline 981819 \\ 1636365 \\ \hline 1637{\cdot}346819 \end{array}$$

Three decimals in the multiplicand and three in the multiplier make 6; that is, 6 places will have to be marked off in the product.

If decimals only are to be multiplied together the rule is the same; but as it then often happens that the number of decimals in both multiplicand and multiplier exceeds the number of figures found in the product, noughts must be

added to the left of the product to complete the number of decimals required.

Example.—Multiply 0·032 by 0·00025.

$$\begin{array}{r} 0{\cdot}032 \\ 0{\cdot}00025 \\ \hline 160 \\ 64 \\ \hline 800 \end{array}$$

Here we must mark off eight places of decimals, and as we have but *three*, five noughts must be added on the left of 8, thus making the product read—

$$0{\cdot}00000800\,;$$

and as noughts on the right of a decimal fraction are of no value, the final product is 0·000008. Remember that the 0 on the left of the decimal point is not a decimal, but that it only shows the place the units would occupy.

DIVISION

The division of decimals differs but little from that of ordinary numbers.

The method we will adopt here is somewhat different from that generally used. I may add that it has stood the test of the classroom, and has been found superior to the other.

RULE 1.—To perform the division of decimals, if both the dividend and divisor have the same number of decimals, remove the decimal point and divide as in the case of ordinary numbers; *e.g.*:—

Divide 1180·65 by 23·15.

$$\begin{array}{r} 2315\,)\,118065\,(\,51 \\ 11575 \\ \hline 2315 \\ 2315 \\ \hline \ldots\ldots \end{array}$$

However, it often happens that the division cannot be performed exactly, and that there is a remainder. In such cases add a nought to that remainder, and proceed with the division as in ordinary cases, taking care, however, to place a decimal point in the quotient before putting any new figure in it.

Example.—Divide 22·75 by 2·13.

```
213 ) 2275 ( 10·
      213
      ---
       1450
```

Thus far the answer is 10, but with remainder 145. We shall then place a nought to the right of the 145, and a decimal point in the quotient. That being done, we shall proceed with the division, which will appear as hereunder:—

```
213 ) 2275 ( 10·6807
      213
      ---
       1450
       1278
       ----
        1720
        1704
        ----
          1600
          1491
          ----
           109 etc.
```

RULE 2.—If the decimals contained in the dividend and divisor are different in number, equalise them by adding noughts to the right of the decimal fraction which contains the smaller number of figures, and proceed as before explained. If one of them only contains decimals, add as many noughts to the other as there are decimals in the other one, *e.g.* :—

Divide 27·0354 by 4·67.

Equalise the number of decimals, and remove decimal point, thus :—

270354 ; 46700.

Then divide 270354 by 46700 as previously explained.

Now suppose we are asked to divide 26 by 178·36.

Let us equalise the number of decimals and remove the decimal point, thus :—

2600 ; 17836.

Then arrange the operation as usual :—

17836) 2600 (quotient

In this case it is evident that there will be no units, a fact which we can indicate at once by writing 0 units in the quotient, and placing the decimal point, thus :—

17836) 2600 (0·

Now, as we cannot divide 2600 by 17836 we add a 0 to the dividend, 2600, and if one nought is not sufficient, we add two, and three, and, in short, as many as will render the division possible; but, and this is very important, instead of adding those noughts at once, we will add them one by one, and, for each nought thus placed to the right of the dividend, we will place one in the quotient to the right of the decimal point, in such a manner as this :—

17836) 2600 (0·00

Adding another nought to 2600 will give us 26000, which can then be divided by 17836, so that instead of putting another 0 in the quotient we shall place, in its stead, the proper figure, in this case 1, and then continue the division in the ordinary way, thus :—

```
17836 ) 26000 ( 0·0014577
        17836
        -----
         81640
         71344
         ------
         102960
          89180
         ------
          137800
          124852
          ------
           129480
           124852
           ------
             4628
```

Another example will make this quite clear:—

Divide 0·00003 by 2·01.

Equalise :—0·00003 and 2·01000.
Remove point :—3 and 201000.

Arrange as usual and proceed as explained :—

```
201000 ) 300000 ( 0·00001492, etc.
         201000
         ------
          990000
          804000
          -------
          1860000
          1809000
          -------
            510000
            402000
            ------
            108000, etc.
```

To Reduce a Vulgar Fraction to a Decimal and *vice versâ.* To reduce a vulgar fraction to a decimal, divide the numerator by the denominator. Thus, to reduce $\frac{3}{4}$ to a decimal divide 3 by 4, and the quotient, 0·75, will be the answer.

To reduce a decimal to a vulgar fraction, write the decimal with its proper denominator and cancel.

Example.—Reduce 0·75 to a vulgar fraction.

$$0{\cdot}75 = \frac{75}{100} = \frac{3}{4}.$$

RECURRING DECIMALS

In the examples just taken, the division has been performed without a remainder. However, this is not always the case, and it happens that, after having found a certain number of figures in the quotient, the figures repeat themselves, and the division does not, and cannot, come to an end.

For instance, if we wish to reduce $\frac{4}{11}$ to a decimal, we find that the figures of the quotient are 0·363636......, the figures 36 continually occurring. Again, if we wish to reduce $\frac{31}{36}$ to a decimal, we find first that the figures of the quotient

are 0·86, after which 1 continually recurs, the quotient being 0·861111 . . . etc.

The first kind of decimal (0·363636......) is called a *pure recurring decimal*, because the figures begin to recur immediately after the decimal point, and the second a *mixed recurring decimal*, because before the figures recur two others have been obtained which do not recur at all.

The recurring figure is indicated by placing a dot over it; *e.g.* 0·3333 should be written $0{\cdot}\dot{3}$. If more than one figure occurs in the period, a dot should be placed over the first and last figures of the period; *e.g.* 0·3793069306 should be written $0{\cdot}37\dot{9}30\dot{6}$.

Now to deal with such recurring decimals is easy enough. If they are to be left as decimals, the ordinary operations of arithmetic can be performed with them in the ordinary way, provided we take a sufficient number of recurring periods to ensure a certain number of decimal places to be correct; or they can be turned into vulgar fractions, and this is often done in the case of multiplication and division.

Rule 1.—To turn a pure recurring decimal into a vulgar fraction, write, for the numerator, the figures which occur in the recurring period, and, for the denominator, as many nines as there are figures in the recurring period, and reduce to lowest terms; *e.g.* $0{\cdot}\dot{7} = \frac{7}{9}$; or,

$$0{\cdot}\dot{1}6\dot{2} = \tfrac{162}{999} = \tfrac{18}{111} = \tfrac{6}{37}.$$

Rule 2.—To turn a mixed recurring decimal into a vulgar fraction, write, for the numerator, the part of the decimal fraction from the decimal point to the end of the first period, subtract from that the figures that do not belong to the recurring part; and, for the denominator, write as many nines as there are figures in the recurring part, followed by as many noughts as there are figures in the non-recurring portion; *e.g.*:—

Reduce $0{\cdot}31\dot{9}30\dot{6}$ to a vulgar fraction.

$$0{\cdot}31\dot{9}30\dot{6} = \tfrac{319306-31}{999900} = \tfrac{319275}{999900}.$$

Then, cancelling by 9, 25, and 11, we shall find respectively:—

$$\tfrac{35475}{111100} = \tfrac{1419}{4444} = \tfrac{129}{404}.$$

REMARK.—The adversaries of decimals—adversaries whose objections not infrequently arise from a want of proper knowledge—make a great deal of the undoubted fact that many vulgar fractions have not, and cannot have, their exact equivalent in decimals. As such persons are not generally to be persuaded, I shall not attempt to do so, but will content myself with stating, for the benefit of those who can listen to reason, that this objection against decimals is perfectly futile. In the first place, as any number of decimals may be obtained, the error can be practically reduced to *nil.* On the other hand, it must be borne in mind that only three decimals will bring us within the thousandth part of an inch, which is not a very great error. If people will only try to divide an inch, I will not say into a thousand, but only a hundred parts, they will be able to form an idea of what a part ten times smaller than a hundredth will be. But the best answer is that in all scientific calculations, all the world over, nothing but decimals are used, and that in astronomical calculations, in the computing of tables of logarithms, and of the various nautical almanacs, nothing but decimals are used, and have been used for several centuries past.

CONTRACTED MULTIPLICATION OF DECIMALS*

When both multiplicand and multiplier contain a great number of decimals, as there would be many more decimal figures in the product than are necessary—three, or, at the most, four decimal places being ample for nearly all calculations—it is unnecessary to go through the ordinary form of multiplying. In such cases an abbreviated method is employed, and this will now be explained.

Multiply 327·245647 by 32·314, so as to have three correct decimal places.

Write down the multiplicand as usual, and since three

* These contracted methods, though not usually found in arithmetic books, are extremely useful. However, they are given in a recent and excellent publication, though somewhat differently explained; but why they should be called Professor de Morgan's Methods, we are at a loss to guess, since these methods were taught in some mathematical treatises written long before the eminent Professor was born.

correct decimals are required place a dot over the *fourth* decimal; that is, take one more decimal in the multiplicand than the number required to be correct. Thus—

$$327\cdot 245\dot{6}47.$$

Next place the multiplier under the multiplicand in such a manner that the figure which indicates the units shall be immediately under the dotted figure—

$$\begin{array}{r@{}l} 327\cdot 245\dot{6} & 47 \\ 2 & \end{array}$$

It now remains to write the figures of the multiplier in their reverse order 41323, instead of 32314, taking care that the units' figure is not shifted. The operation will then be ready for working.

$$\begin{array}{r@{\;}l}
327\cdot 245\dot{6}47 & \\
41323 & \\
\hline
981\ 7\ 3694 & \\
65\ 4\ 4913 & \\
9\ 8\ 1737 & \\
3\ 2725 & \\
1\ 3090 & \\
\hline
1057\ 4\cdot 615\cancel{9} &
\end{array}$$

EXPLANATION.—Take the 3 on the right hand of the multiplier and multiply the figure on the right hand of the one immediately above it by that figure; that is, multiply 7 by 3, but only see what the product is, and do not write it down. If this product should be between 5 and 15, carry one; if between 15 and 25, carry two; if between 25 and 35, carry three, and so forth.

In the case we are now dealing with $3 \times 7 = 21$, so that as that product falls between 15 and 25 we shall carry two. This being done, multiply the next figure by 3, and add the 2 carried from the preceding product; that is, $3 \times 4 = 12 + 2 = 14$. Write down the 4, and continue to multiply the whole line in the ordinary way.

For the second line take the second figure of the multiplier, 2 in this instance, and multiply by it the figure on the right hand of the one immediately above it, 4. Twice 4 are 8; as that falls between 5 and 15 we shall carry one, and proceed as for the first line.

The decimal point will be placed four places from the right of the product, and as only three correct places of decimals are wanted, cut off the last decimal on the right of the product.

Another example will now be given, and, by way of contrast, the ordinary method will also be shown.

Find the product of 13·12345672 by 2·04312743, to four correct places of decimals.

```
 13·12345672
3472 13402
-----------
  26 24691
     52494
      3937
       131
        26
         9
-----------
  26·81288
```

The full multiplication is as follows:—

	13·12345672
	2·043312743
	39 37037016
	524 9382688
9	196 419704
26	246 91344
131	234 5672
3937	037 016
52493	826 88
26 24691	344
26·81289	450 10498296

It will be noticed that all the figures on the right side of the double line have been saved; that is, instead of 117 figures, only 48 have been used, thus effecting a saving of 69 figures.

It may also be noted that the figures on the left of the double line are the ones that form the partial products seen in the contracted form, but occurring in the reverse order.

If the multiplicand only contains two decimals it may be convenient to add noughts to it, so as to have three or four correct places. Above all things, remember that the number of decimal places in the product is always shown by the rank of the decimal in the multiplicand under which the units' figure of the multiplier is placed.

In working with decimals it is usual to increase by one the last decimal taken if the one that follows it is either 5, 6, 7, 8, or 9. This practice still further reduces the error.

According to this, the answer to the above multiplication might be 26·8129.

However, if only a certain number of *correct* decimals is required, the decimals should be left as found.

If the multiplicand contains a great number of noughts, after the decimal point, and relatively but few integers, it is as well to add one or more noughts to the right of the decimal part, so as to place the units figure of the multiplier under the last original figure of the multiplicand. The following example will make this clear:—

Multiply 0·00000849 by 3·1416.

$$
\begin{array}{r}
0{\cdot}000008490 \\
61413 \\
\hline
25470 \\
849 \\
340 \\
8 \\
5 \\
\hline
0{\cdot}000026672
\end{array}
$$

Note that in multiplying by 6 we say 6 times 8 are 48, which gives us 5 to carry on, and as 6 times 0 are nothing we simply put down the 5.

CONTRACTED DIVISION

There are several ways of performing this operation, and the one chosen here is as simple as any.

Look upon the numbers as ordinary numbers, then take, in the divisor, as many figures as you wish to have in the quotient, and divide by these only.

For instance, if we wish to divide 10574·6155 by 327·245647, and to have five figures, including decimals, in the quotient, arrange the operation as usual, and without any regard to the decimal point, and mark off five figures in the divisor, thus:—

$$
\begin{array}{r}
3)2)7)2)4]\cancel{5}\cancel{6}\cancel{4}\cancel{7})\,105746155\,(32313 \\
\underline{98173} \\
7573 \\
\underline{6545} \\
1028 \\
\underline{982} \\
46 \\
\underline{33} \\
13 \\
\underline{13} \\
\ldots
\end{array}
$$

Now divide 105746 by 32724; place the proper figure (3) in the quotient. Multiply the divisor by the quotient figure, and carry, as you did in the case of contracted multiplication, the product of the preceding figure cut off (5), reckoning 1 from 5 to 15; 2 from 15 to 25; 3 from 25 to 35, and so on.

To obtain the second figure of the quotient, divide the remainder 7573 by 3272—not by 32724—that is by one figure fewer than before. This will give 2 in the quotient, with remainder 1028. Now cut off another figure from the divisor, and this will now be 327. Divide 1028 by this shortened divisor 327, and proceed in the same manner until there are no more divisors left.

Now, where shall we place the decimal point? After the first figure of the quotient has been found, and the first product written down under the dividend, note under what

figure of the dividend the product of the units figure of the divisor happens to be. In this case the product of the units figure of the divisor falls under the 7 of the dividend. Now, if we look at the dividend given, 10574·6155, we shall see that this 7 occupies the second place on the *left* of the decimal point. That will tell us that we must have two figures before the decimal point in the quotient, so that the final answer is 32·314. If this figure should happen to fall under the decimal part of the dividend, the rank it will occupy in that decimal part will indicate the rank of the first figure found in the quotient.

Another example will make this clear.

Divide 0·0062145 by 3·00567 and find five figures.

```
3)0)0)5)6]7)62145(20676
            60113
            -----
             2032
             1803
             ----
              229
              210
              ---
               19
               18
               --
                1
```

The product of the units figure (3) falls under the 6 of the dividend, and this 6 occupies the third rank in the given dividend 0·0062145. Therefore the first figure of the quotient (2) must also occupy the third rank in the answer, which in this case will be

0·0020676.

The shortness of this mode of operating can be fully appreciated if the ordinary division is performed. To obtain the same number of figures in the quotient, more than treble the number of figures is usually required. In the first example ninety-two figures would be required where only twenty-nine have been used. The chances of mistakes are also minimised.

There is also another common way of shortening a division, but not to the same extent. It consists in not writing down the figures of the partial products obtained by multiplying the figures of the divisor by those of the quotient, and in

immediately subtracting the figure found from the one under which it should stand, and in borrowing a number of tens sufficient to render the subtraction possible. An example worked both ways will speak for itself.

Divide

```
489327)844089075(1725
       489327
       -------
       3547620
       3425289
       -------
        1223317
         978654
        -------
        2446635
        2446635
```

```
489327)844089075(1725
       3547620
        1223317
         2446635
         .........
```

This way of performing the division is called, in England, the *Italian method*, but why, is not very clear, since it is universally used on the Continent, except with very young beginners. I see no reason why it should not be used in English schools since there is, on the contrary, every reason why it should be used.

Facts Worth Remembering about Decimals :—

To multiply a number by 0·5 is to halve it.
" " 0·25 " quarter it.
" " 0·75 " take three-quarters of it.
" " 1·25 " " it once and a quarter.
" " 1·50 " " " half.
" " 1·75 " " " three-quarters.

Therefore

$\frac{1}{2}$ of anything expressed in decimals is 0·5.
$\frac{1}{4}$ " " " 0·25.
$\frac{3}{4}$ " " " 0·75.
$1\frac{1}{4}$ " " " 1·25.
$1\frac{1}{2}$ " " " 1·50.
$1\frac{3}{4}$ " " " 1·75.

To *multiply* a number by 0·5 *divide* it by 2.
" " 0·25 " 4.
" " 0·75 " $\frac{3}{4}$.

To *divide* a number by 0·5 *multiply* it by 2.
" " 0·25 " 4.
" " 0·75 " $\frac{4}{3}$.

CHAPTER IV.

GENERAL PRINCIPLES OF THE METRIC SYSTEM

THE unit of linear measure is the *metre*, a word derived from the Greek *metron*, "a measure." The name *metric*, from *metre*, has been given to the system because all the standards of weights and measures are derived from the *metre*.

The *metre* is assumed to be the ten-millionth part of an arc of the meridian extending from the pole to the equator, that is, to the ten-millionth part of the distance between pole and equator. Since that distance was measured by Delambre and Méchain, it has been found that the metre first adopted as the standard in France, and subsequently in other countries, is too short. However, the error, if error it really be, is so very slight that, far from reflecting discredit on those to whom the work was originally entrusted, it reflects the greatest credit on them, since the platinum metre kept in the Palais des Archives, in Paris, is only too short by about the eighth part of a millimetre, a quantity which the keenest eyesight could not detect, for it is impossible to see clearly the eighth part of a millimetre without a magnifying glass. Anyhow, even admitting that such a mistake was made, it does not detract, in any way, from the value of the system, and it must also be borne in mind that such a trifling error practically leaves the metre the ten-millionth part of the distance between pole and equator.

Besides, were the mistake ever so much greater, it would not render the system less valuable than it has proved itself to be.

The great beauty and value of the Metric System is that all its measures are derived from one unique standard, and

that all the multiples and sub-multiples of its measures, being decimal, agree with our system of notation, which is also decimal. This means that any weight or any measure of the Metric System, together with its multiples and sub-multiples, can be written with as little trouble as we write ordinary numbers.

The units of weights and measures of the Metric System are the following:—

1.	The **Metre** . . .	Unit of	**Linear Measure.**
2.	„ **Are** . . .	„	**Area.**
3.	„ **Stere** (or Cubic Metre)	„	**Volume.**
4.	„ **Litre** . . .	„	**Capacity** (Liquid and Dry Measures.)
5.	„ **Gramme** . . .	„	**Weight.**
6.	„ **Franc** . . .	„	**Money.**

The **Are** is a square the side of which is equal to ten linear metres. It therefore contains 100 square metres.

The **Stere** is a cube the side of which is equal, in length, to one linear metre. It is, then, the same thing as a cubic metre.

The **Litre** is a cube the side of which is equal to the tenth part of a linear metre.

The **Gramme** is the weight of a cubic centimetre of distilled water at its maximum density, in a vacuum.

Such are the original units of the Metric System. We say original, because they have undergone some slight modifications, which, however, leave the system untouched. Thus the *stere*, as we shall see further on, is now scarcely spoken of, except for one particular kind of measure. The *are* also is not universally used, and the number of square metres it represents is often mentioned instead of it, so that, especially in the case of small plots of land, it is more usual to speak of 200 or 300 *square metres* of ground than of two or three *ares*.

It must be again said that these are matters of detail which, far from detracting from the value of the system, show, on the contrary, and as we shall presently see, that any measure, any of its multiples or sub-multiples, can be used as a unit with the greatest facility, and that we may choose among the ordinary units, or their multiples or sub-multiples, whichever of them is most convenient for our purpose, and that without the least complication in calculations.

In short, the Metric System is a most pliable and obedient instrument, since it is equally adapted to the most common calculations of commerce, and to the most precise and minute computations of the scientific man.

MULTIPLES AND SUB-MULTIPLES

The names of the multiples are formed by the simple process of placing before the name of the unit one of the prefixes **deca, hecto, kilo,** or **myria,*** meaning respectively 10, 100, 1000, 10000 times the unit. Thus:—

1 **Deca**metre	=	10 metres.
1 **Hecto**metre	=	100 ,,
1 **Kilo**metre	=	1000 ,,
1 **Myria**metre	=	10000 ,,

and so on for every unit; the same prefix always meaning the same thing whatever be the unit. Thus, **deca** will always be **ten times** the unit, whatever that unit may be. If a *decametre* is *ten metres*, a *decalitre* is *ten litres*, and a *decagramme ten grammes.*

The sub-multiples are formed by placing before the names of the units one of the prefixes **deci, centi, milli,** meaning respectively, $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{1000}$. Thus:—

1 **Deci**metre	=	$\frac{1}{10}$ or 0·1	of a metre.
1 **Centi**metre	=	$\frac{1}{100}$ or 0·01	,,
1 **Milli**metre	=	$\frac{1}{1000}$ or 0·001	,,

The same prefix always means the same thing, whatever be the unit to which it is prefixed.

Deci will always stand for **one-tenth** of the unit, **centi** for **one-hundredth**, and **milli** for **one-thousandth**. . A *centimetre* will be the *hundredth* part of a *metre*, a *centigramme* the *hundredth* part of a *gramme*, and so on.

It may as well be stated, at once, that in such a system no tables whatever have to be learnt. All that is necessary to express all the weights and measures of the Metric System is to know thirteen words—the names of the six units and the names of the multiples and sub-multiples.

* For the origin of the above words see p. 95.

The few exceptions to this rule are an outgrowth, and, though sanctioned by general practice, they may be followed or not, according as it is convenient to do so or not.

Thus it is usual, in France, to express the multiples of the *stere* and *are* in ordinary numbers, and to say "ten steres" instead of 1 "decastere," and "ten ares" in the place of "1 decaare" or "decare." The reason of these exceptions can easily be explained. The stere being a common measure for wood fuel, it is not often that people have occasion to order or to sell more than two or three *steres* at a time, and in the case of the *are*, either a plot of land is too small to measure more than a few *ares*, or, if of any importance, the *hectare* is, as we shall see further on, the unit most commonly used.

The Metric System is also called the *Decimal System of Weights and Measures*, because its multiples and sub-multiples always express numbers which are either 10, 100, 1000, etc., times greater or smaller than the unit. This being so, each multiple is ten times greater than the next lower one, and ten times smaller than the next greater one.

Thus a "hectometre" is ten times a "decametre," whilst it is the tenth part of a "kilometre."

The same may be said of the sub-multiples, with the difference that the sub-multiples express quantities which are the tenth, the hundredth, and the thousandth part of the unit. A "centimetre," for instance, will be ten times smaller than a "decimetre," and ten times larger than a "millimetre."

With such a system reduction is an easy matter, and simply consists in shifting the decimal point. Thus the length denoted by 72327·752 metres can be expressed in either of the following ways:—

72327·752 metres = 7232·7752 decametres,
or = 723·27752 hectometres,
or = 72·327752 kilometres,
or = 7·2327752 myriametres;

or in sub-multiples = 723277·52 decimetres,
or = 7232775·2 centimetres,
or = 72327752 millimetres.

Again, a length of 3 kilometres, 5 hectometres, 6 decametres, 7 metres, 8 decimetres, 9 centimetres, can be expressed in any of the following ways:—

3·56789 kilometres,
or 35·6789 hectometres,
or 356·789 decametres,
or 3567·89 metres,
or 35678·9 decimetres,
or 356789 centimetres.

In calculations

myria is placed in the rank of the **tens of thousands**,
kilo " " " **thousands**,
hecto " " " **hundreds**,
deca " " " **tens**;

and the sub-multiples—

deci is placed in the rank of **tenths**,
centi " " " **hundredths**,
milli " " " **thousandths.**

As it is often necessary, or desirable, either

(1) to find the reciprocal value of the multiples and sub-multiples; or,
(2) to transform multiples into sub-multiples, and *vice versâ*; or,
(3) to separate a multiple from its sub-multiples; or,
(4) to write down quantities of different names,

we will now explain how these various operations are to be accomplished, and it will be seen that nothing can be easier. All that is needed is to bear in mind the following simple table, in which stand, on either side of the units, the multiples and the sub-multiples with their respective values, whatever be the unit.

MULTIPLES.				UNITS.	SUB-MULTIPLES.		
MYRIA.	KILO.	HECTO.	DECA.		DECI.	CENTI.	MILLI.
10,000	1,000	100	10		0·1	0·01	0·001

To find the Reciprocal Value of the Multiples and Sub-multiples.—Now let us suppose it is required to find how many *decas* make a *myria*; that will fall under the first heading, namely, that of finding the reciprocal value of multiples and sub-multiples.

Starting from column "deca," there are three places to reach "myria"; that is, there are 1,000 decas in a myria.

If the reverse question were asked—for instance, how many "decis" are there in a "kilo"?—count the number of places from "kilos" to "decis," not omitting the unit column; that is, four places, therefore add four noughts, and thus

1 kilo = 10,000 decis.

To transform Multiples into Sub-multiples, and *vice versâ*. Reduce 25 *kilos* into *centis*. Count the number of places in the table from "kilo" to "centi," including the units column. As there are five places, therefore to write twenty-five "kilos" into "centis" we must add five noughts—

25 kilos = 2,500,000 centis.

How many kilos in 350,000,000 millis? Count as before, but instead of adding the noughts cut them off. In this case six noughts will be cut off, and therefore

350,000,000 millis = 350 kilos.

If there were other figures they would be left, and the decimal point used. Thus—

How many kilos in 12345678 centis?
Answer = 123·45678 kilos.

To Separate a Multiple from its Sub-multiple.—In 4,356 units place the decimal point to indicate "decas," then "hectos," and then "kilos."

Begin at the units column, and see how many places there are to reach "decas," then "hectos," then "kilos." For "decas" it is one place, for "hectos" two, and for "kilos" three; therefore in 4,356 units there are

435·6 decas,
43·56 hectos,
4·356 kilos.

Again, separate the decas from 69,898 millis. From "millis" to "decas" there are four places, therefore the answer is 6·9898 decas.

To write down Quantities of Different Names.—Add together 55 kilos, 16 decas, 17 hectos, 3 decis, 5 centis, 2 millis. Reduce all the multiples to units thus:—

$$\begin{aligned} 55 \text{ kilos} &= 55000, \\ 16 \text{ decas} &= 160, \\ 17 \text{ hectos} &= 1700; \end{aligned}$$

and as for the sub-multiples, write them down after the decimal point according to the order—"deci" in the place of the "tenths," "centi" in that of the "hundredths," and "milli" in that of the "thousandths." Then

$$\begin{aligned} 3 \text{ decis} &= 0 \cdot 3, \\ 5 \text{ centis} &= 0 \cdot 05, \\ 2 \text{ millis} &= 0 \cdot 002; \end{aligned}$$

then add the quantities as in ordinary cases of addition of decimal fractions thus:—

$$\begin{array}{r@{}l} 55000 & \\ 160 & \\ 1700 & \\ 0 & \cdot 3 \\ 0 & \cdot 05 \\ 0 & \cdot 002 \\ \hline 56860 & \cdot 352 \end{array}$$

Now, with a little practice, even this very simple table can be entirely dispensed with, and indeed it is only of use to beginners. In a very short time any number can be transformed, or written down, without the least difficulty. However, to make matters perfectly clear to private students, I will now explain the process of writing down any quantity without reference to the table, and it will be seen that it actually takes much longer to explain the process than to perform the thing.

The only rule consists in knowing the sequence of the multiples and sub-multiples both ways, so as to be able, at any moment, to repeat mentally the words:—

Myria, kilo, hecto, deca, units; deci, centi, milli;

Or **Milli, centi, deci, units; deca, hecto, kilo, myria.**

Nothing more is required.

If we were asked for instance to write 75 kilos in millis, we should first write 75, then say mentally after it, "hecto," "deca," "units," "deci," "centi," "milli," putting down a nought for each one, thus:—

Kilos.	Hecto.	Deca.	Units.	Deci.	Centi.	Milli.
75	0	0	0	0	0	0

That is 75,000,000 millis.

If we were now asked to reduce

73475 units to kilos,

then, starting from the right-hand figure (5 in this case), we should proceed the reverse way and say "units," "deca," "hecto," "kilo." This would carry us to the 3, which would indicate the kilos, thus:—

Kilos.	Hecto.	Deca.	Units.
73	4	7	5

the answer being 73·475 kilos.

Although the student may be told that fractions of a kilogramme are written merely as ordinary decimals, which is true enough, and that the names of the multiples and sub-multiples below kilogrammes need not be learnt, I think otherwise. Far from simplifying matters, it only complicates them. Besides, there is nothing particularly difficult in this chapter, nothing, at any rate, that the most ordinary intellect may not master with a little work.

Before finishing this chapter the student must also be shown how any multiple or sub-multiple of any unit can be itself used as a unit. Nothing indeed can be simpler.

Suppose, for instance, that we were asked to write a certain weight—and this is the usual practice—in kilogrammes and fractions of a kilogramme, such, for instance, as 275 kilogrammes 785 grammes. We should simply write it thus: 275·785 kilogrammes, and not 275 kilogrammes 7 hectogrammes 8 decagrammes and 5 grammes. If asked to write 275 kilogrammes 85 grammes, do not write 275·85, but 275·085 kilogrammes, since hectogrammes come immediately after kilogrammes, and as in this case there are none, a nought must indicate their place.

Write 20 metres 75 millimetres
Answer: 20·075 metres.

The nought after the decimal point here takes the place of the decimetres.

Write 10 kilometres 35 metres 95 centimetres in metres.
Answer: 10035·95, since there are 1000 metres in one kilometre.

The numerous examples found at the end of this book will afford the student plenty of practice, all the more so as they are of a practical nature, and such as actually have to be performed in the course of ordinary business transactions.

CHAPTER V.

LINEAR MEASURES, OR MEASURES OF LENGTH

THE **metre** is the **unit** of measure **of length.** The multiples of the metre are :—

The	**decametre**	=	10 **metres.**
„	**hectometre**	=	100 „
„	**kilometre**	=	1000 „
„	**myriametre**	=	10000 „

And the sub-multiples :—

The	**decimetre**	=	$\frac{1}{10}$ or 0·1	**metres.**
„	**centimetre**	=	$\frac{1}{100}$ or 0·01	„
„	**millimetre**	=	$\frac{1}{1000}$ or 0·001	„

The *decametre* is generally used as a unit in land surveying, whilst the *hectometre*, the *kilometre*, and the *myriametre* are commonly used to express the length of roads or railways.

On French roads every *kilometre* is indicated by a stone, and on most of them there is also a smaller stone at every *hectometre.*

The *millimetre* is sufficiently small for any ordinary measurement, since it is about the twenty-fifth part of an inch. When greater accuracy is required, as in engineering, optics, etc., the millimetre is further divided into ten parts, and those parts into ten others, and so on.

The metre is equal to 39·37079 inches, or to 1·0936331 yards.
„ kilometre „ 0·6213824 miles „ 1093·6331 „

Hence it follows that a kilometre is about five furlongs.

As it is often convenient to turn yards into metres, and *vice versâ*, this can be done roughly by reckoning 10 metres as equal to 11 yards.

It is also convenient to remember that 5 miles are almost exactly equal to 8 kilometres.

As in all other cases, the operations are reduced to ordinary additions, subtractions, multiplications, and divisions, either with or without decimals, as the case may be.

A few examples will now make this clear.

Read :—

135·75 metres.—Answer : One hundred and thirty-five metres and seventy-five centimetres.

0·037 metres.—Answer : Thirty-seven millimetres.

13·500 kilometres.—Answer : Thirteen kilometres and five hundred metres, or thirteen kilometres and a half.

Write in figures :—

Seventeen metres and five centimetres.—Answer : 17·05.

Three hectometres and nine decimetres.—Answer : 300·9 metres.

Two kilometres, three hectometres, four decametres, five metres.—Answer : 2345 metres.

2345 metres in decametres, in hectometers, and in kilometres.—Answers : 234·5 decametres, 23·45 hectometres, 2·345 metres.

Five millimetres.—Answer : 0·005 metres.

How many centimetres are there in 10320 millimetres?—Answer : 1032 centimetres.

How many millimetres are there in ten metres?—Answer : 10000 millimetres.

Add together: 5·15 metres + 6·017 metres + 17·128 metres + 0·007 metres.

$$\begin{array}{r} 5{\cdot}15 \\ 6{\cdot}017 \\ 17{\cdot}128 \\ 0{\cdot}007 \\ \hline 28{\cdot}302 \end{array}$$

Answer : 28 metres and 302 millimetres.

Multiply : 7·21 metres × 3·12.

$$\begin{array}{r} 7{\cdot}21 \\ 3{\cdot}12 \\ \hline 1442 \\ 721 \\ 2163 \\ \hline 22{\cdot}4952 \end{array}$$

Or, by contracted multiplication :—

```
 7·210
   213
 -----
 21630
   721
   144
 -----
22·495
```

Answer : 22·495 metres.

In ordinary cases two or three decimals are quite sufficient. 22·495 should be read 22 metres 495 millimetres, or simply 22 metres decimal 4, 9, 5.

REMARK.—In working with decimals it should be noted that, for all general purposes of trade, two, and at most three, decimals are all that is required, and that four and five decimals are hardly ever wanted, except where special accuracy is required. This being so, the short multiplication should be practised, as it shortens the work considerably.*

Examples.

1. How many kilometres are there in 1 myriametre, 10 hectometres, 642 hectometres, 1000 myriametres, 22275 decametres?

1 myriametre	=	10	kilometres.
10 hectometres	=	1	"
642 "	=	64·2	"
1000 myriametres	=	10000	"
22275 decametres	=	222·75	"
Total		10297·95	,

2. How many metres are there in the distances given in No. 1?

1 myriametre	=	10000	metres.
10 hectometres	=	1000	"
642 "	=	64200	"
1000 myriametres	=	10000000	"
22275 decametres	=	222750	"
Total		10297950	"

* See page 36.

3. A bar of iron, which should be 3·495 metres long, is only 29 decimetres 3 centimetres 4 millimetres long. What length should be added to it to have the required length?

29 decimetres	=	2·9	metres.
3 centimetres	=	0·03	"
4 millimetres	=	0·004	"
Total length		2·934	"

which must be subtracted from 3·495 :—

$$\begin{array}{r} 3{\cdot}495 \\ 2{\cdot}934 \\ \hline 0{\cdot}561 \end{array}$$

Answer: 0·561 metres.

It is usual, on the Continent, to read 0·561 metres not as a fraction of a metre, but by giving the decimal part the denomination of the smallest sub-multiple; so that, instead of saying "no metres, decimal 5, 6, 1," it is usually read as "561 millimetres."

4. In the construction of a suspension bridge 4,865 bundles of wire have been used. Supposing each bundle contained 107·75 metres, say how many metres have been employed. Also how many hectometres and kilometres.

Multiply the number of bundles by the length of each, thus:—

$$\begin{array}{r} 4865 \\ 107{\cdot}75 \\ \hline 24325 \\ 34055 \\ 34055 \\ 4865 \\ \hline 524203{\cdot}75 \end{array}$$ metres.

Since a hectometre is equal to 100 metres, we must divide the product by 100:—

Answer: 5242·0375 hectometres.

A kilometre being 1000 metres, divide the product by 1000:—

Answer: 524·20375 kilometres.

We could have got the last answer directly from the hectometres by simply recollecting that 1 kilometre is equal to 10 hectometres, that is, by dividing 5242·0375 hectometres by 10.

5. If the distance between two points is 9 hectometres 75 metres 375 millimetres, how many times will a length of 25·50 metres be contained in it?

Reduce all to metres, thus :—

9 hectometres	=	900	metres
75 metres	=	75	"
375 millimetres	=	0·375	"
		975·375	metres.

Now perform the division as indicated on page 31.

```
25500)975375(38·25
      76500
      ------
      210375
      204000
      ------
       63750
       51000
      ------
      127500
      127500
      ------
      ......
```

Or by short division—

```
2550)975375(3825
     7650
     ----
     2103
     2040
     ----
       63
       51
       --
       12
       12
       --
      ...
```

Answer: 38·25.

Note that the distance is given in hectometres, metres, and millimetres merely for the sake of practice, and not as is usually done, since dimensions are always given in a certain unit followed by its decimals.

CHAPTER VI.

SQUARE AND LAND MEASURE

THE **unit** of **area** is the **square metre**, that is, a square each side of which is equal to one metre in length. It is used as the unit by builders, painters, carpenters, etc. The sub-multiples of the square metre are used in the measurement of small surfaces. The multiples are :—

The **square**	**decametre** *	=	100	**square metres.**
„	**hectometre**	=	10,000	„
„	**kilometre**	=	1,000,000	„
„	**myriametre**	=	100,000,000	„

The sub-multiples are :—

The **square**	**decimetre**	=	$\frac{1}{100}$ or 0·01	**square metre.**
„	**centimetre**	=	$\frac{1}{10000}$ or 0·0001	„
„	**millimetre**	=	$\frac{1}{1000000}$ or 0·000001	„

The *square decametre*, being a square the side of which contains 10 linear metres, will of course contain 10 × 10, or 100 square metres. The *square hectometre*, being a square the side of which contains 100 linear metres, will contain 100 × 100, or 10,000 square metres.

In like manner it will be found that a *square kilometre* contains 1,000,000 square metres, and a *square myriametre* 100,000,000 square metres. It will also be readily seen that

1 *square kilometre*	=	100	square	hectometres,
or	=	10,000	„	decametres,
or	=	1,000,000	„	metres,

and that

1 *square hectometre*	=	100	square	decametres,
or	=	10,000	„	metres.

* The square decametre is little used, hence 100 square metres is the expression generally employed in its stead.

The sub-multiples will be better understood from the following diagram :—

Fig. I.

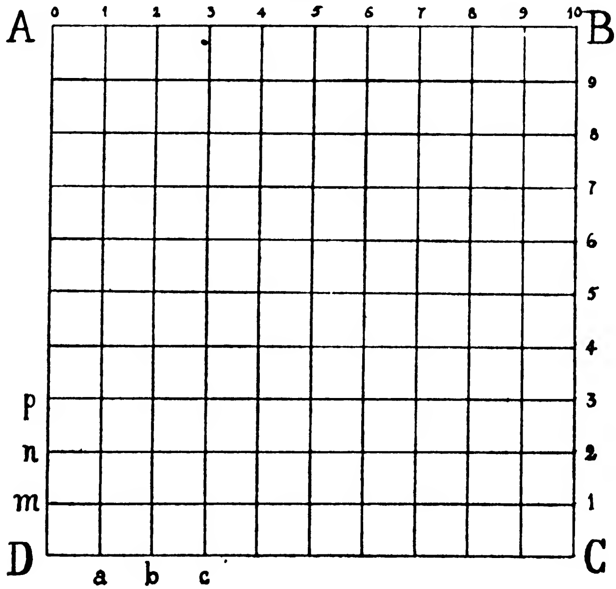
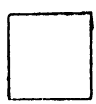


Fig. II.



If *AB* is supposed equal to 1 metre in length, the figure being a square, the other sides will all be equal to 1 metre, and the space *ABCD*, inclosed by the four sides, will represent a square metre.

Now if *AB* is divided into ten equal parts, 1, 2, 3, etc., each part will be equal to the tenth part of a linear metre, that is, to a linear decimetre.

If we now divide *BC* in a similar manner, and if from the points 1, 2, 3, etc., in *AB* the lines 1*a*, 2*b*, 3*c* be drawn parallel to *BC*, and if from the points 1, 2, 3, etc., in *BC* lines 1*m*, 2*n*, 3*p*, etc., be drawn parallel to *AB*, the whole square, *ABCD*, will have been divided into 100 little squares, each side of which will be in length equal to 1 linear decimetre. It will then follow that each little square will be a square decimetre, and that there are therefore 100 square decimetres in a square metre.

Now if the side of each little square were further divided into ten parts, that square decimetre would contain 100 smaller squares, each equal to a square centimetre; and as there would be 100 square centimetres in each square decimetre, there would be 100 times more, or 10,000, in a square metre. In Fig. II. is shown the real size of a square centimetre.

In the same manner it can be shown that the number of square millimetres in a square metre is equal to 1,000,000, since 100 × 100 × 100 = 1,000,000. Therefore:—

1 square metre	=	100	**square**	**decimetres,**
or	=	10,000	„	**centimetres,**
or	=	1,000,000	„	**millimetres.**
1 square decimetre	=	100	„	**centimetres,**
or	=	10,000	„	**millimetres.**
1 square centimetre	=	100	„	**millimetres.**

Note, therefore, that the hundredth part of a square metre is not a square centimetre, but a square decimetre. This will be best understood if the student will carefully study the diagram, and draw it for himself, making *AB* exactly equal to 1 linear decimetre.

Now as 100 square decimetres make 1 square metre, it is evident that

two	figures	should	represent	**square**	**decimetres,**
four	„	„	„	„	**centimetres,**
and **six**	„	„	„	„	**millimetres.**

Thus, 2·25 square metres should be read 2 square metres and 25 square decimetres, while 2·000025 square metres will stand for 2 square metres and 25 square millimetres.

In writing the sub-multiples, we must therefore bear in mind that for each class of sub-multiples there must be two figures, since we may have to express as many as 99 square decimetres, or 9999 square centimetres, or 999999 square millimetres. There again a study of the diagram will be most useful.

If the number of figures given for each class is inferior to 10, a nought on the left must indicate the place of the other figure. Thus, 1 square metre and 5 square decimetres must not be written 1·5, but 1·05, just as 2 square metres and five centimetres must be written 2·0005 and not 2·005.

If the number of figures following the decimal point is not even, a nought should be added to the right to transform the decimal fractions into sub-multiples. Thus, 2·3 square metres, that is, 2 square metres and $\frac{3}{10}$, should be read 2 square metres and 30 square decimetres. In short, as has been said, two figures must be used for each sub-multiple, and noughts must supply the place of those wanting.

Write 3 square metres and 5 square millimetres.

Square metres.	Square decimetres.		Square centimetres.		Square millimetres.	
3	0	0	0	0	0	5
	tens.	units.	tens.	units.	tens.	units.

which should be written 3·000005 square metres.

Also note that the tenth of a square metre is not the same as a square decimetre, nor the hundredth the same as the square centimetre, nor the thousandth the same as the square millimetre.

If we had to read the following number—

1·234567 square metres,

we could read it in either of the following ways:—

1 square metre 23 square decimetres 45 square centimetres and 67 square millimetres; or

1 square metre 234,567 square millimetres.

The latter is indeed the usual way.

TOPOGRAPHICAL MEASURES

To measure large extents of territory like a county, or a whole country like England, France, Germany, three units are generally used. However, they are not new ones, but only multiples of the square metre, and just as the kilometre and myriametre are used as the units of long distances, so are the square kilometre and square myriametre when large areas are to be measured.

These measures will therefore require no further explanation. However, as we have to do with square measure, it must be noted that after square myriametres we may have to express as many as 99 square kilometres, since a square myriametre contains 100 square kilometres. We must always have two figures to express square kilometres, and also two figures for square hectometres, and so on.

AGRARIAN OR LAND MEASURES

These measures are used for land, such as estates, woods, small forests, fields, etc. The **unit** of **land measure** is the **are**,* which is a square the side of which is equal, in length, to 10 linear metres. Hence the are covers an area of 100 square metres. It is, then, the same thing as a square decametre. The only multiple of the are in use is the **hectare**, which contains 100 ares, so that its area $= 100 \times 100$ or 10,000 square metres. Hectares are usually counted by tens, hundreds, and thousands.

The hectare is equal to about $2\frac{1}{2}$ English acres.

The **are** has one sub-multiple: the **centiare**, which is the hundredth part of the are.

The **centiare** is the same as the **square metre**. Although there may seem to be an anomaly in the land measures, it is not really so; for if there are no such measures as the decaare or decare, and kiloare, it is because those square measures are respectively equal to 1,000 and 100,000 square metres, representing squares the sides of which cannot be expressed exactly, since there is no exact square root to 1,000 or 100,000.

* See page 44.

Now, since 100 centiares = 1 are, and 100 ares = 1 hectare, it is evident that we may have to express as many as 99 centiares, or 99 ares, so that these measures must always be represented by two figures each.

Thus, 7·1595 hectares should be read 7 hectares 15 ares 95 centiares.

If only units of ares and units of centiares are given, noughts must indicate the place which the **tens** of ares and centiares would occupy: therefore 15 hectares 3 ares 5 centiares must be written 15·0305 hectares, and not 15·35, which would mean 15 hectares 35 hundredths of a hectare, that is, 35 ares.

Examples.

1. How many square metres, etc., are there in the following areas? (*a*) 4 square decimetres 426 square millimetres; (*b*) 150·765 square decimetres; (*c*) 73·20001 square metres; (*d*) 45 square decimetres and 3 square centimetres; (*e*) 4·032 square decimetres.*

		Deci.	centi.	milli.
(*a*) 4 square decimetres 426 square millimetres	=	0·04	04	26
(*b*) 150·765 square decimetres . . .	=	1·50	76	50
(*c*) 73·20001 square metres . . .	=	73·20	00	10
(*d*) 45 square decimetres 3 square centimetres .	=	0·45	03	00
(*e*) 4·032 square decimetres . . .	=	0·04	03	20
Total	=	75·23	87	06

Answer: 75·238706 square metres; read either as "75 square metres, decimal 2, 3, 8, 7, 0, 6," or, as on the Continent, "75 square metres 238 thousand 706 square millimetres."

2. A carpet is made up of 5 strips, each 0·50 metres wide and 4·95 metres long. It is surrounded by a border 0·35 metres wide. Find (*a*) the area covered by it, (*b*) the area left uncovered, if it be laid in a room 6·45 metres long by 4 wide, and (*c*) the width of floor left uncovered.

Width of carpet = 5 × 0·50 = 2·50 metres, to which must be added twice the width of the borders, that is 2 × 0·35 = 0·70.

Total width = 2·50 + 0·70 = 3·20 metres.

Length of carpet = 4·95 + twice width of border;

= 4·95 + 0·70 = 5·65 for the total length.

Area covered by carpet = 5·65 × 3·20 = 18·08 square metres.

Area of room = 6·45 × 4 = 25·80 square metres.

* Remember that you must have two figures for square decimetres, four for square centimetres, and six for square millimetres.

The difference of area is naturally the area left uncovered, or

$$25 \cdot 80 - 18 \cdot 08 = 7 \cdot 72 \text{ square metres.}$$

The width left uncovered will be the difference between the width of the room and that of the carpet; or,

$$4 \text{ metres} - 3 \cdot 20 \text{ metres} = 0 \cdot 80 \text{ metres.}$$

That should be divided by 2, as the carpet is presumably laid so as to leave an even space uncovered all round. Therefore

$$0 \cdot 80 \div 2 = 0 \cdot 40 \text{ metres.}$$

The width of floor left uncovered the other way will be the difference between the length of the room and the length of the carpet, or $6 \cdot 45 - 5 \cdot 65 = 0 \cdot 80$, also divided by $2 = 0 \cdot 40$.

Answers: (*a*) 18·08 square metres; (*b*) 25·80 square metres; (*c*) 0·40 metres (40 centimetres).

3. What is the difference between the following areas in square metres?

3,728 square-hectometres and 2,752 hectares 43 ares.

Since 1 square hectometre contains 10,000 square metres, 3,728 square hectometres will contain $3{,}728 \times 10{,}000 = 37{,}280{,}000$ square metres.

Also as 1 hectare = 100 ares and 1 are = 100 square metres,

Therefore

1 hectare $= 100 \times 100 = 10{,}000$ square metres, and 2,752 hectares contain $2{,}752 \times 10{,}000 = 27{,}520{,}000$ square metres, and 43 ares $= 43 \times 100 = 4{,}300$ square metres, and 2752 hectares, and 43 ares $= 27{,}520{,}000 + 4{,}300 = 27{,}524{,}300$ square metres.

Difference: $37{,}280{,}000 - 27{,}524{,}300 = 9{,}755{,}700$.

Answer: 9,755,700 square metres.

Note that 1 square hectometre and 1 hectare contain the same area.

4. How many *ares* are there in (*a*) 2,871 hectares, (*b*) in 200 centiares, (*c*) in 7,427 centiares?

(*a*) 1 hectare = 100 ares, then 2,871 hectares $= 2{,}871 \times 100 = 287{,}100$ ares.

(*b*) Since 1 centiare is the hundredth part of an are, if we divide 200 centiares by 100 we shall have the number of ares:—

$$200 \div 100 = 2 \text{ ares.}$$

(*c*) In the same manner 7,427 centiares $= 7{,}427 \div 100 = 74 \cdot 27$, or 74 ares and 27 centiares.

5. A farm consists of the following plots of land, (*a*) 30 hectares 5 ares 6 centiares, (*b*) 8 hectares 10 ares 20 centiares, (*c*) 3 hectares 78 ares 75 centiares, (*d*) 12 hectares 12 centiares, (*e*) $\frac{1}{2}$ hectare, and (*f*) $\frac{3}{4}$ are. What is the total area?

									Hectares.
(*a*)	30	hectares	5	ares	6	centiares	=		30·0506
(*b*)	8	”	10	”	20	”	=		8·1020
(*c*)	3	”	78	”	75	”	=		3·7875
(*d*)	12	”	—		12	”	=		12·0012
(*e*)	$\frac{1}{2}$	”	—		—		=		0·5000
(*f*)	—		$\frac{3}{4}$	”	—		=		0·0075
									54·4488

Answer: 54 hectares 44 ares and 88 centiares.

6. How many square kilometres in (*a*) 400 hectares and (*b*) 500,000 ares?

First find the relation between the hectare and the square kilometre, as is shown below. This value will be found in Table I. (page 98), but the student should calculate it as an exercise, for it must be remembered that, with the decimal system, all possible calculations can be performed without reference to tables of any sort. Since the hectare is a square the side of which is equal to 100 linear metres, it therefore contains $100 \times 100 = 10{,}000$ square metres. Since the square kilometre is a square the side of which is equal to 1,000 linear metres, it therefore contains $1{,}000 \times 1{,}000 = 1{,}000{,}000$ square metres.

Divide the one by the other, and you will see at a glance that the hectare is contained 100 times in a square kilometre, since

$$\frac{100\cancel{0}\cancel{0}\cancel{0}\cancel{0}}{1\cancel{0}\cancel{0}\cancel{0}\cancel{0}} = 100.$$

Then, since 100 hectares = 1 square kilometre,

$$1 \quad ” \quad = \tfrac{1}{100} \quad ” \quad ”$$

$$\text{and } 400 \quad ” \quad = \tfrac{400}{100} = 4 \text{ square kilometres.}$$

Again, since the are is a square the side of which is equal to 10 linear metres, it contains $10 \times 10 = 100$ square metres; and as the square kilometre contains 1,000,000 square metres, there are therefore $\frac{10000\cancel{0}\cancel{0}}{1\cancel{0}\cancel{0}} = 10{,}000$ ares in a square kilometre.

Since 10,000 ares = 1 square kilometre,

$$1 \text{ are} = \frac{1}{10000}$$

$$\text{And } 500{,}000 \text{ ares} = \frac{50\cancel{0}\cancel{0}\cancel{0}\cancel{0}}{1\cancel{0}\cancel{0}\cancel{0}\cancel{0}} = 50 \text{ square kilometres.}$$

CHAPTER VII.

CUBIC MEASURE AND MEASURES OF CAPACITY

THE **unit of cubic measure** is the **cubic metre**, that is, a cube every side of which is one metre in length.

The cubic metre alone is employed, and is never joined on to the words expressing the multiples, so that we speak of 10, 100, 1,000 cubic metres, and not of a "cubic decametre," "cubic hectometre," or "cubic kilometre." The reason of this is obvious, for such multiples would not convey to the mind the same impression as in the case of linear or square measure, and, just as we do not speak of "cubic miles," we do not speak of "cubic kilometres."

The sub-multiples of the cubic metre will now be explained, and a reference to the diagram on next page will make them clear.

Let *ABCDEFLH* be a cube, every side of which is assumed to be 1 metre long.

Now if the side *AB* is divided into 10 parts, and *BC* also into 10 parts, and parallel lines be drawn, as in the case of the square metre, on page 58, it will be seen that the square *ABCD* has been divided into 100 smaller squares, which are *square decimetres*.

Now if on each of these little squares we build a cube, as the little shaded cube *V*, it is evident that 100 such cubes will be necessary to cover the whole square *ABCD*.

Since all the sides of the larger cube are equal—that is to say, as its breadth, length, and height, or depth are equal to 1 linear metre—it is clear that the whole cube, if divided into smaller cubes like *V*, would contain ten layers of 100 cubes each, that is 1,000 of them, and, as each of these small cubes would represent the volume of 1 **cubic decimetre**, it follows therefore that 1 **cubic metre** contains 1,000 **cubic decimetres**.

Fig. III.

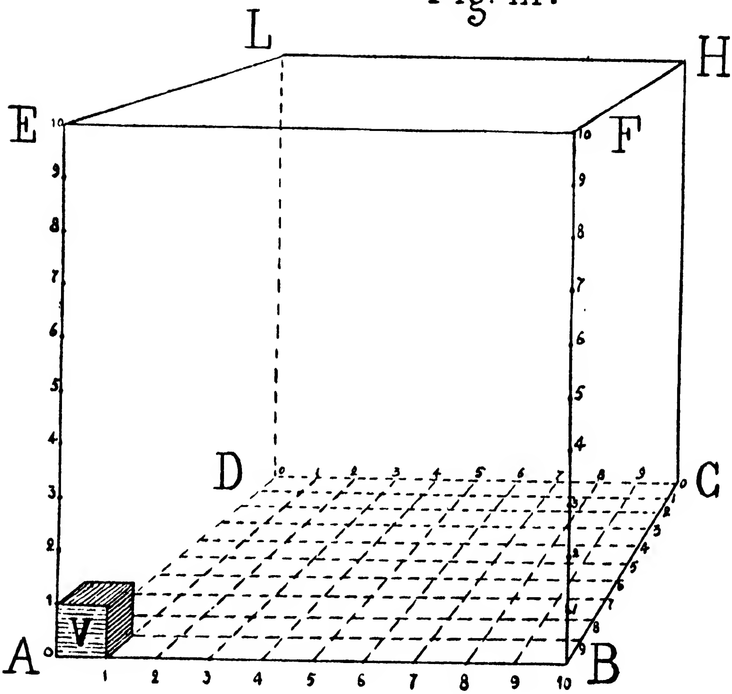
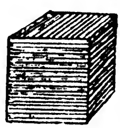


Fig. IV.



Now if we divide each little cube *V* in a similar manner, each one of them will contain 1,000 still smaller cubes, and as the side of these smaller cubes would be equal in length to 1 centimetre, these smaller cubes would then be cubic centimetres. Now if the small cube *V* contains 1,000 cubic

centimetres, the whole cube *ABCDEFLH*, which already contains 1,000 cubes like *V*, will contain 1,000 times more such smaller cubes, that is, $1{,}000 \times 1{,}000 =$ **1,000,000 cubic centimetres**. In like manner it will be found that the number of cubic millimetres is equal to $1{,}000 \times 1{,}000 \times 1{,}000$, that is, 1,000,000,000.

If the diagram given were the exact size of a cubic decimetre, the little cube *V* would then be the exact representation of the cubic centimetre. However, it is a good deal smaller, but Fig. IV. shows its real size in perspective.

It follows therefore that

1 cubic metre	=	**1,000**	**cubic**	**decimetres,**
or	=	**1,000,000**	„	**centimetres,**
or	=	**1,000,000,000**	„	**millimetres;**
that the **cubic decimetre**	=	**1,000**	„	**centimetres,**
or	=	**1,000,000**	„	**millimetres;**
and that **1 cubic centimetre**	=	**1,000**	„	„

Hence we must not take the cubic decimetre for the tenth part of the cubic metre, nor the cubic centimetre for the hundredth part of it, nor the cubic millimetre for the thousandth part of a cubic metre.

It is then obvious that in dealing with cubic measure we may have to express as many as 999 cubic decimetres, or 999,999 cubic centimetres, or 999,999,999 cubic millimetres; hence each class of sub-multiples must be expressed by three figures, and, if only units of each are given, the tens and hundreds must be represented by noughts.

If we have to write 5 cubic metres 227 cubic decimetres 27 cubic centimetres and 9 cubic millimetres, we should write it as follows:—

Cubic metres.	Cubic decimetres.			Cubic centimetres.			Cubic millimetres.		
5·	2	2	7	0	2	7	0	0	9
	hundreds.	**tens.**	**units.**	**hundreds.**	**tens.**	**units.**	**hundreds.**	**tens.**	**units.**

That is, 5·227027009 cubic metres.

If we were asked to read 15·563000007 cubic metres we should say: 15 cubic metres 563 cubic decimetres, and 7

cubic millimetres; or, 15 cubic metres 563,000,007 cubic millimetres.

As in the case of other measures, the sub-multiples can be taken as units, and this is actually the case if the volume or capacity of small things is required.

The cubic metre is the unit used for measuring stone, excavation work, and so forth.

The **stere** is a **cubic metre**, and is used for measuring wood in logs. It consists of a framework with upright posts. (See page 90.)

The *stere* has one multiple: the **decastere = 10 steres**; and one sub-multiple: the **decistere** = $\frac{1}{10}$ **of a stere.**

It is usual to reckon by *steres* rather than by *decasteres*, and to say "10 *steres*" instead of "1 *decastere*."

The *decistere* being the tenth part of the *stere*, or of a cubic metre, the figure representing decasteres must be written in the place of the tenth, that is immediately after the decimal point, and not as *cubic decimetres*, which are the thousandth part of the metre. Decasteres are represented by one figure only, since ten of them make a stere.

The figures 17·3 steres should be read 17 steres 3 decasteres.

MEASURES OF CAPACITY, OR LIQUID AND DRY MEASURES.

These are used to measure liquids, such as water, wine, spirits, beer, oil, and milk; and they are called "liquid measures." When used to measure corn, oats, beans, or seeds of any sort, etc., they are denominated "dry measures." The **unit of measures of capacity** in the Metric System is the **litre,** which is a vessel containing exactly **1 cubic decimetre.** However, as the cubic shape is not very convenient for practical purposes, the litre is usually a metallic or wooden measure of cylindrical shape, the contents of which is in every case equal to 1 cubic decimetre. (See pages 91, 92.)

The multiples of the litre are:—

The	**decalitre**	=	**10 litres.**
„	**hectolitre**	=	**100** „
„	**kilolitre**	=	**1,000** „

The sub-multiples are :—

The **decilitre** = $\frac{1}{10}$ **of a litre.**
„ **centilitre** = $\frac{1}{100}$ „

The *myrialitre* and *millilitre* are never used, and the expression "1000 litres" is more common than *kilolitre.*

Nothing more need be said about these measures, except that, if the *hectolitre* is taken as the unit, as it often is, the first decimal figure will express decalitres, the second litres, and so on. If the *decalitre* were taken as the unit, then the first decimal figure would stand for *litres*, the second for *decilitres*, and so on.

In the wholesale wine trade the "hectolitre" is used as the unit, and in the retail trade the "litre" and "decilitre" are most used as wine measures, and the "centilitre" as a spirit measure.

The "hectolitre" is also the unit in the wholesale corn trade, and the "litre" and "decilitre" the common retail measures.

The *litre*, it may be useful to remember, is rather more than $1\frac{3}{4}$ pints, or, decimally, 1·75 pints. This value is useful in rough calculations.

Examples.

1. Add together: 275·32 cubic metres + 75 cubic centimetres + 32·3721045 cubic metres + 0·03 cubic metre + 997 cubic millimetres + 227 cubic centimetres.*

			Deci.	centi.	milli.
275·32 cubic metres . .	=	275·	320	000	000
75 cubic centimetres . .	=	0·	000	075	000
32·3721045 cubic metres .	=	32·	372	104	500
0·03 cubic metre . .	=	0·	030	000	000
997 cubic millimetres . .	=	0·	000	000	997
227 cubic centimetres . .	=	0·	000	227	000
		307·	722	407	497

Answer: 307·722407497 cubic metres.

* Remember that you must have 3 figures for cubic decimetres, 6 for cubic centimetres, and 9 for cubic millimetres, although in practice the noughts to the right, as in line 1, are omitted, and 275·320 alone would be written.

2. How many steres are there in a pile of wood 47·75 metres long, 22·47 metres wide, and 17·33 metres in height?

Cubical contents of pile $= 47{\cdot}75 \times 22{\cdot}47 \times 17{\cdot}33$.

As three decimals will be ample in such a sum as this, the short multiplication can be used with advantage.

$$\begin{array}{r}
47{\cdot}75000 \\
7422 \\
\hline
9550000 \\
955000 \\
191000 \\
33425 \\
\hline
1072{\cdot}9425 \\
3371 \\
\hline
10729425 \\
7510597 \\
321883 \\
32188 \\
\hline
18594{\cdot}093
\end{array}$$

Answer: 18594·093 cubic metres; and as the stere and the cubic metre are the same—18594·092 steres.

The decimal part is not a number of decisteres, for the decistere being the tenth part of the stere, the decisteres should be in the place of the 0. The three decimals therefore only express a fraction of a stere, in this case $\frac{92}{1000}$, which of course is not quite a decistere, though somewhat near it.

3. How many flasks will be wanted to contain 74 litres 25 centilitres of scent, if each flask contains 0·27 litres?

We must of course find how many times 0·27 will go into 74·25; that is, we shall have to divide 74·25 by 0·27.

Equalise decimals as mentioned on page 32, Rule II.

$$\begin{array}{l}
27\,)\,7425\,(\,275 \\
\quad\;\; \underline{54} \\
\quad\;\; 202 \\
\quad\;\; \underline{189} \\
\qquad 135 \\
\qquad \underline{135} \\
\qquad \ldots
\end{array}$$

Answer: 275 flasks.

4. How many hectolitres of wine are there in four casks containing respectively: (*a*) 3 hectolitres 75 litres, (*b*) 2 hectolitres 9 litres, (*c*) 3 hectolitres 19 litres, (*d*) 2 hectolitres 97 litres? If the total contents have to be divided among 24 persons, what will be the share of each?

(*a*)	3	hectolitres	75	litres	= 3·75	hectolitres,
(*b*)	2	,,	9	,,	= 2·09	,,
(*c*)	3	,,	19	,,	= 3·19	,,
(*d*)	2	,,	97	,,	= 2·97	,,
					12·00	,,

Since 1 hectolitre = 100 litres, 12 hectolitres = 1,200, which, divided by 24, give 50 litres.

Answers: { (*a*) 12 hectolitres;
(*b*) 5 decalitres, *or* 50 litres.

5. What are 12 hectolitres in cubic measure?

Since 1 litre = 1 cubic decimetre,
1 hectolitre = 100 litres = 100 ,, ,,
and 12 hectolitres = 12×100 = 1200 ,, ,,
or 1·2 cubic metres.

Answer: 1·2 cubic metres.

CHAPTER VIII.

MEASURES OF WEIGHT

THE **unit of weight** is the **gramme,** which, as we have seen (p. 44), is the weight of a cubic centimetre of distilled water at its greatest density in a vacuum.

The multiples of the gramme are:—

The	**decagramme**	=	**10**	**grammes.**
,,	**hectogramme**	=	**100**	,,
,,	**kilogramme**	=	**1,000**	,,
,,	**myriagramme**	=	**10,000**	,,

The sub-multiples are:—

The	**decigramme**	=	$\frac{1}{10}$	or **0·1**	**of a gramme.**
,,	**centigramme**	=	$\frac{1}{100}$	or **0·01**	,,
,,	**milligramme**	=	$\frac{1}{1000}$	or **0·001**	,,

Therefore:—

1 *myriagramme*	=	10	*kilogrammes,*
or	=	100	*hectogrammes,*
or	=	1,000	*decagrammes,*
or	=	10,000	*grammes;*
1 *kilogramme*	=	10	*hectogrammes,*
or	=	100	*decagrammes,*
or	=	1,000	*grammes;*
1 *hectogramme*	=	10	*decagrammes,*
or	=	100	*grammes;*
1 *decagramme*	=	10	*grammes;*
1 *gramme*	=	10	*decigrammes;*

and so on.

It is more usual to speak of 10 kilogrammes than of 1 myriagramme.

To those measures must also be added the **quintal**, weighing **100 kilogrammes**, and the **metric ton**, equal to **1,000 kilogrammes.**

The kilogramme and half kilogramme being very convenient weights, and also more frequently used than any others, the kilogramme is generally taken as the unit in the retail trades.

However, the *gramme* and its sub-multiples are the units employed by goldsmiths and chemists.

This choice of unit does not in any way affect the mode of working.

Naturally, if the kilogramme is taken as the unit—

The **first figure** on the right, after the decimal point, will represent **hectogrammes**;

The **second one, decagrammes**;

The **third, grammes.** Thus,

227·724 kilogrammes

means 227 kilogrammes 7 hectogrammes 2 decagrammes 4 grammes; or, simply 227 kilogrammes and 724 grammes.

If the gramme is the unit, then—

The **first figure** on the right, after the decimal point, represents **decigrammes**;

The **second, centigrammes**; and

The **third, milligrammes.** Thus,

12·213 grammes

can be read 12 grammes 2 decigrammes 1 centigramme 3 milligrammes; but is usually read, on the Continent, as 12 grammes 213 milligrammes.*

* The decimal system of weights and measures not being used in England, it is of course impossible to say what the general practice of reading such quantities might be. It is not unlikely that, in accordance with the usual way of reading decimals, in England, such quantities might be read in a similar way, without giving the decimal part its proper denomination, that is reading simply as 12 grammes decimal 2, 1, 3. What has been followed here is the Continental way, for abroad it is the usual and general practice to give any decimal its proper denomination, whether dealing with abstract or concrete numbers. This method is, to the author's knowledge, the one adopted in Belgium, France, Germany, Italy, Spain, and Switzerland.

Examples.

1. What is the total weight, in kilogrammes, of the following? 227 kilogrammes 95 grammes + 17·5 kilogrammes + 1,227 grammes + 32,700 centigrammes + 10 kilogrammes 10 hectogrammes 10 decagrammes.

227 kilogrammes 95 grammes	=	227·095
17·5 "	=	17·500
1,227 grammes	=	1·227
32,700 centigrammes	=	0·32700
10 kilogrammes 10 hectogrammes 10 decagrammes	=	11·100
		257·24900

N.B.—In the last quantity note that 10 hectogrammes are the same as 1 kilogramme, since 10 hectogrammes = 10 × 100 grammes = 1,000 grammes, and also that 10 decagrammes = 10 × 10 grammes = 100 grammes = 1 hectogramme.

In practice such a weight would be given as 11 kilogrammes 100 grammes.

2. The water contained in a cubical vase weighs 40 kilogrammes. What are the cubical contents of that vase?

Since 1 kilogramme of water is equal to the volume of 1 cubic centimetre, 40 kilogrammes = 40 cubic decimetres, or 0·040 cubic metre.

Answer: 40 cubic decimetres.

3. If a cistern 2·15 metres long by 0·75 wide and 0·95 high is filled with water to a distance of 0·15 metres from the top, find:

(*a*) The cubical contents of the cistern;
(*b*) The volume of water it contains;
(*c*) The weight of that water.

Cubical contents of cistern = 2·15 × 0·75 × 0·95 = 1·531875 cubic metres.

As the height of the water in the cistern is less than the height of the cistern by 0·15, the depth of the water in it equals 0·95 − 0·15 = 0·80.

Therefore the volume of the water is

2·15 × 0·75 × 0·80 = 1·290 cubic metres.

Since the volume of a cubic decimetre of pure water* weighs 1 kilogramme, 1,290 cubic decimetres of water will weigh 1,290 kilogrammes, supposing the water contained in the cistern to be pure. The difference between the weight of pure water and that of ordinary water need never be taken into account in ordinary calculation, for the difference is a very trifling one.

* See p. 97, the word "Kilogramme."

CHAPTER IX.

COINAGE

THE unit of money in France is the **franc**, in Germany the **mark,** whilst in Spain, Italy, and other countries, forming what is known as the "Latin Union," it is a coin equal in value and fineness to the *franc*. In Italy this coin is called *lira* (plural *lire*), in Spain *la peseta*, in Switzerland the *franc*, in Greece the *drachma*.

Whatever be the coin, or the value of it, the mode of working is not altered, and the sub-multiples are always decimal parts of the unit, whatever the unit may be.

In the Metric System the words denoting multiples are never prefixed to the name of the monetary units, so that we speak of 10, 100, 1,000 francs, or lire, or marks, and not of *decafrancs* or *hectomarks*.

The franc is divided into ten parts called *decimes*, and each decime into ten other parts called *centimes*. It must be noticed, at once, that these words are slightly different from the usual nomenclature, which ought to be *decifranc* and *centifranc*, words which, however, are never used.

A **franc** contains, then, 10 **decimes,**
or 100 **centimes,**
or 1000 **milliemes.**

The latter, *millieme*, is never used in ordinary calculations, for which francs and centimes alone are used.

As has been proposed, on more than one occasion, the English coinage could easily be made decimal, whilst still keeping the pound sterling as the unit. In that case the florin would still be, as it now is, the tenth part of a pound. If this system should ever be adopted, then the pound sterling would be divided into 10 florins, the florin into 10 *cents*, and the cent into 10 *mils*. So that

£1 would be equal to 10 florins, or 100 cents, or 1,000 mils.

Such a modification would much simplify the working of arithmetical operations, especially if decimals were used throughout at the same time.

The following examples, worked side by side, will speak in favour of the introduction of a decimal system of accountancy:—

Suppose we were asked to find the interest on a sum of £350 for 76 days at 4 per cent.

First Method.
(By decimals.)

£350 Principal.
4 Rate per cent.
1400
0·2082 (76 days as a decimal of a year.)
2800
112
28
2·914800 = Answer.

That is £2·915, which would be read: 2 pounds 9 florins 1 cent 5 mils, or simply 2 pounds 915 mils.

£2·915 in the present coinage gives by inspection

£2 18*s.* $3\frac{3}{5}$*d.*

On this side 29 figures only are used.*

Second Method.
(The ordinary way.)

£350 Principal.
76 Days.
2100
2450
26600
4 Rate per cent.
365) 1064,00 (£2
730
334
20
365) 6680 (18*s.*
365
3030
2920
110
12
365) 1320 (3*d.*
1095
225
4
365) 900 (2
730
160

Answer: £2 18*s.* $3\frac{1}{2}$*d.*

By this method 90 figures are used.

* As it might be objected, and with some reason, too, that we have not worked out the decimal part of a year and that this shortens the

As for the working of accounts in decimal coinage, it does not differ from the working of ordinary decimals.

In France and the "Latin Union" the decimal point is placed after the francs, and the decimal part is always expressed in centimes. Now as *centimes* are hundredths, they must be represented by two figures, so that if the number of centimes given is expressed by one figure only, a **0** must take the place of the tenths. Thus 5 francs 5 centimes should be written:—

5·05 francs.

I must once more repeat that it does not matter in the least whether the unit used be the *franc*, the *mark*, or the *pound*, so long as everything is divided decimally. It is with money as with other measures, and any multiple can be taken as the unit. The kilogramme is an instance of this, since, as has been said before (see p. 73), it is oftener taken as a unit than the gramme. In the keeping of accounts two columns only are wanted, one for the units and one for the figures standing on the right of the decimal point.

Examples.

1. How many francs and centimes are there in 10 decimes, 4789 centimes, 100 centimes, 16,987 centimes, 18 francs and 95 centimes, 202 centimes, 742 francs and 10 decimes?

		Francs centimes.
10 decimes . . .	=	1·00
4789 centimes . .	=	47·89
100 centimes . . .	=	1·00
16987 centimes . .	=	169·87
18 francs 95 centimes .	=	18·95
202 centimes . . .	=	2·02
742 francs and 10 decimes	=	743·00
Total	=	983·73

Answer: 983·73 francs; that is, 983 francs and 73 centimes.

operation, we must add that a table of the decimal parts of a year is usually handy, and that the calculation in question need not be made. Even if it had to be made it would only add a few figures more, so that the unquestionable shortness of the decimal method is unimpeached. (See Table VII., page 108.)

2. A landlord whose rates amount to 4789 francs 15 centimes has already paid 3299 francs 95 centimes; how much has he still to pay?

Subtract 3299·95 from 4789·15.

$$\begin{array}{r} 4789{\cdot}15 \\ \underline{3299{\cdot}95} \\ 1489{\cdot}20 \end{array}$$

Answer: 1489·20 francs.

3. What amount will have to be paid weekly for the wages of 385 workmen, each receiving 27·45 francs?

Multiply 27·45 by 385.

$$\begin{array}{r} 27{\cdot}45 \\ \underline{3\ 85} \\ 137\ 25 \\ 2196\ 0 \\ \underline{8235} \\ 10568{\cdot}25 \end{array}$$

Answer: 10568·25 francs.

4. If 649 steres 8 decisteres of firewood have cost 22,743 francs, how much is that per stere?

Divide 22,743 by 649·8 steres, thus:—

$$\begin{array}{r} 6498)227430(35 \\ \underline{19494} \\ 32490 \\ \underline{32490} \\ \dots\dots \end{array}$$

Answer: 35 francs per stere.

5. Find the interest on a sum of 22795·75 francs at $4\frac{1}{4}$ per cent. for 301 days.

First write $4\frac{1}{4}$ as a decimal: 4·25.

Now if 100 francs yield $4{\cdot}25$

1 franc will yield $\frac{4{\cdot}25}{100}$

and 22795·75 francs ,, $\frac{4{\cdot}25 \times 22795{\cdot}75}{100}$

In one day this would yield 365 times less, or $\frac{4{\cdot}25 \times 22795{\cdot}75}{100 \times 365}$

and in 302 would yield 302 times more, or $\frac{4{\cdot}25 \times 22795{\cdot}75 \times 302}{100 \times 365}$

By suitably cancelling, and working out, the answer will be found to be 801·59; that is 801 francs and 60 centimes, since 59 centimes are considered equal to 60 in business.

Now if, as is almost universally done in business abroad, a table of the decimals of a year is used, the working is at once much simplified, since the denominator will be at once reduced to 100.

In this case 302 days are equal to 0·8274 of a year, therefore

$$\text{if 100 francs yield} \quad 4{\cdot}25 \quad \text{per cent.,}$$

$$\text{1 franc will yield} \quad \frac{4{\cdot}25}{100} \quad \text{,,} \quad \text{and}$$

$$22795{\cdot}75 \text{ francs} \quad \text{,,} \quad \frac{4{\cdot}25 \times 22795{\cdot}75}{100} \quad \text{,,}$$

This is the yield for one year, and the yield for 0·8274 of a year will be

$$\frac{4{\cdot}25 \times 22795{\cdot}75 \times 0{\cdot}8274}{100}$$

Working this by contracted multiplication we find the following scheme :—

$$\begin{array}{r}
22795{\cdot}750 \\
524 \\
\hline
91183\ 000 \\
4559\ 150 \\
1139\ 787 \\
\hline
96881{\cdot}937 \\
4\ 728 \\
\hline
775055\ 496 \\
19376\ 387 \\
6781\ 735 \\
387\ 527 \\
\hline
80160{\cdot}1145
\end{array}$$

This result has now only to be divided by 100 by moving the decimal point, and, as only two decimals are kept, the answer is

801·60 francs.

N.B.—On page 108 will be found this most useful table of decimals of a year, re-calculated with the greatest care, and giving the nearest approximation possible with four decimals.

This table will only do for countries in which the commercial year is composed of 365 days, as in England, the Colonies, and America, but not in those countries in which the commercial year is made up of 12 months of 30 days each, that is of 360 days only.

CHAPTER X.

EQUIVALENT PRICES

As it is often indispensable, in business, to find the price, in English money and English measurement, of an article priced in foreign money and measured according to the Metric System, we will now show how this can be effected, and also how the reverse operations can be performed. The following typical examples will fully illustrate the process, and they will also show us that the price of an article sold at so many francs per half kilogramme is not to be found, as we are usually told, by simply turning roughly the number of francs and centimes into pence, and taking the kilogramme as equal to 2 lbs. In other words, we must not say that an article sold in France at the rate of 1 franc per half kilogramme would cost in England 10d. per lb.

PROBLEM I.

If 1 metre of stuff cost 7·50 francs, what is that per yard in English money, £1 being worth 25·20 francs?

£1 = 25·20 francs; 1 metre = 39·37 inches.

If 39·37 inches cost 7·50 francs, 1 inch costs $\frac{7 \cdot 50}{39 \cdot 37}$; and

36 inches cost $\frac{7 \cdot 50 \times 36}{39 \cdot 37}$ in francs (A).

If 25·20 francs are worth £1 (= 240 pence), 1 franc is worth

$\frac{240}{25 \cdot 20}$; and the amount (A) in francs so much more.

Therefore 36 inches cost $\frac{7 \cdot 50 \times 36 \times 240}{39 \cdot 37 \times 25 \cdot 20}$ in pence = $65\frac{1}{4}d.$

= $5s.$ $5\frac{1}{4}d.$ = Answer.

PROBLEM II.

If 1 yard of silk cost 3*s.* 10*d.*, what is that per metre in French money?

39·37 inches = 1 metre; 25·15 francs = £1.

If 36 inches cost 3*s.* 10*d.*, or 46 pence, one inch cost $\frac{46}{36}$ pence;

and 39·37 inches cost, in pence, $\frac{46 \times 39{\cdot}37}{36}$ (A).

Now, if 240 pence are worth 25·15 francs, 1 penny is worth $\frac{25{\cdot}15}{240}$; and the number of pence (A) so much more,

$$\text{that is } \frac{46 \times 39{\cdot}37 \times 25{\cdot}15}{36 \times 240};$$

$$= 5{\cdot}27 \text{ francs} = \text{Answer.}$$

PROBLEM III.

If 1 lb. of something cost 3*s.* 2*d.*, what is that per kilogramme in francs and centimes?

£1 = 25·15 francs; 1 kilogramme = 2·2 lbs.

1 kilogramme (= 2·2 lbs.) at 38*d.* will cost 2·2 × 38 = 83·6*d.*

If 240*d.* are worth 25·15 francs,

1*d.* is „ $\frac{25{\cdot}15}{240}$;

and 83·6 are „ $\frac{25{\cdot}15 \times 83{\cdot}6}{240}$

= 8·77 francs = Answer.

PROBLEM IV.

If the litre cost 0·75 franc, what is that per gallon, in English money, if the sovereign is worth 25·20 francs?

1 gallon = 4·543468 litres; £1 = 25·20 francs.

Therefore 1 gallon costs in francs 4·543468 × 0·75 = 3·45 francs.

Now if 25·20 francs are worth 240 pence,

1 franc is „ $\frac{240}{25{\cdot}20}$;

and 3·45 francs are „ $\frac{240 \times 3{\cdot}45}{25{\cdot}20} = 32{\cdot}85$ pence,

that is, 2*s.* 8¾*d.* (rather more) = Answer.

Problem V.

If butter of the best quality be sold in Paris at the rate of 4·50 francs per kilogramme, how much is that per pound in English money?

1 kilogramme = 2·2 lbs; £1 = 25·15 francs.

Therefore if 2·2 lbs. cost 4·50 francs,

1 lb. " $\frac{4{\cdot}50}{2{\cdot}2}$ in francs (A).

If 25·15 francs are worth £1 = 240 pence,

1 franc is " $\frac{240}{25{\cdot}15}$,

and the amount of francs in (A) so much more.

Therefore 1 lb. cost in pence $\frac{4{\cdot}50 \times 240}{2{\cdot}2 \times 25{\cdot}15} = 19{\cdot}51$ pence

= a little over 1*s.* 7½*d.* = Answer.

Problem VI.

What are 7 square yards and 4 square feet in French square measure?

1 square yard or 9 square feet = 0·83610 square metre.
7 square yards = 63 square feet.
7 square yards + 4 square feet = 67 square feet.

Now if 9 square feet = 0·83610,

1 " foot = $\frac{0{\cdot}83610}{9}$;

and 67 " feet = $\frac{0{\cdot}83610 \times 67}{9} = 6{\cdot}2243$.

Answer: 6·2243 square metres.

PROBLEM VII.

If 2 hectares 20 ares of land have been sold for 12570 francs, what is that per acre in English money, assuming the pound sterling to be worth 25·15 francs?

$$\text{Price of 1 hectare} = \frac{12570}{2\cdot20} = 5713\cdot65.$$

$$1 \text{ hectare} = 2\cdot4711431 \text{ acres.}$$

$$\text{Therefore 1 acre} = \frac{1}{2\cdot4711431} = 0\cdot404671 \text{ of a hectare.}$$

And 1 acre in francs costs $0\cdot404671 \times 5713\cdot65 = 2312\cdot15$ francs.

$$\text{Now } £1 = 25\cdot15 = 240 \text{ pence,}$$

$$1 \text{ franc is worth } \frac{240}{25\cdot15};$$

$$\text{and } 2312\cdot15 \text{ francs are } ,, \quad \frac{240 \times 2312\cdot15}{25\cdot15}$$

$= 22064\cdot25$ pence $= £96$ 2*s.* $0\frac{1}{4}$*d.* (nearly) = Answer.

PROBLEM VIII.

Find the value of 3721·75 francs in English money, if £1 = 25·18 francs.

$$\text{If } 25\cdot18 \text{ francs} = £1, \ 1 \text{ franc} = \frac{1}{25\cdot18};$$

$$\text{and } 3721\cdot75 = \frac{3721\cdot75}{25\cdot18} = £147 \ 16s. = \text{Answer.}$$

PROBLEM IX.

Find the value of £600 18*s.* in francs, if 25·27 = £1.

If £1 = 25·27 francs, £600 18*s.* are worth £600 18*s.* × 25·27;

but £600 18*s.* = £600·9;

Therefore £600·9 × 25·27 = 15185·65 francs = Answer.

CHAPTER XI.

REMARKS ON THE CHANGE OF MONEY, ETC.

THE daily value of the exchange between London and Paris should be carefully noted, for, on large sums of money, the market value often makes a considerable difference. Many English people are surprised to find that there is no difficulty whatever, in Paris, in changing a sovereign for 25 francs, and that waiters, in *cafés*, will take sovereigns without the least hesitation. There is little reason for wonder, since the French Mint will always take a sovereign for 25·15 francs. Hence a person changing 100 sovereigns in a day, at the rate of 25 francs, can always make sure of getting, for each of them, 25·15 francs, and may be more. Now this difference of 0·15 centimes on 100 sovereigns would amount to as much as 15 francs. I have known the value of the sovereign to rise to 25·37.

On a large sum this would amount to several pounds, as will be seen from the following examples:—

Suppose, for instance, that we have to change a sum of £1000, and that £1 is worth either 25·15 francs or 25·37 francs.

1st case £1000 at 25·15 francs = 25150 francs;

2nd „ „ 27·37 „ = 25370 „

Difference = 220 francs, that is about £8 15*s*.

It must not be imagined, as some people do, that this value of the sovereign is the result of some peculiar property of "English gold." It is no such thing, and is merely due to the fact that the sovereign contains more actual gold. As for the various qualities of gold, 18-carat gold is the same in value all the world over; so is 22-carat.

It may be noted, by the way, that all articles of gold sold in France must be 18 carats, and that to sell anything under that standard is strictly prohibited. French goldsmiths are allowed to manufacture jewellery under that standard, on the distinct understanding that it is for exportation, and that it will never be offered for sale in France.

CHAPTER XII.

HANDY RULES FOR QUICK CONVERSION FROM OR INTO THE METRIC SYSTEM, INTO OR FROM THE ENGLISH SYSTEM

Money.

French prices may be turned *roughly* into shillings and pence as follows:—

Rule 1.—For an even number of francs add a **0** to the right, and that will give the number of pence, *e.g.*:—

1 franc = 10*d.* = 10*d.*
3 francs = 30*d.* = 2*s.* 6*d.*

This is pretty correct up to five francs.

Rule 2.—If there are francs and centimes, take the first two figures on the left, and they will represent the pence. If the last figure on the right is a five, add a halfpenny, *e.g.*:—

2·70	francs	= 27	pence	= 2*s.* 3*d.*
1·80	"	= 18	"	= 1*s.* 6*d.*
2·95	"	= 29½	"	= 2*s.* 5½*d.*

Rule 3.—To turn shillings and pence into francs and centimes add all pence together. If there is no halfpenny, write down the number of pence, add **0** to the right, and mark off two decimals. If there is a halfpenny, add **5** instead of **0**; *e.g.*:—

2*s.* 4*d.*	= 28	pence	= 2·80	francs.
3*s.* 6½*d.*	= 42½	"	= 4·25	"

For sums of five shillings and above it is better to take

4*s.* = 5 francs.
10*s.* = 12·50 francs.
£1 = 25 francs: or,
5 francs = 4*s.*
10 " = 8*s.*
20 " = 16*s.*

MILES INTO KILOMETRES, AND *Vice Versâ.*

Miles can be turned into kilometres quickly by remembering that 5 miles are nearly equal to 8 kilometres.

To turn miles into kilometres multiply the number of miles by 8 and divide the product by 5.

To turn kilometres into miles multiply the number of kilometres by 5 and divide the product by 8.

Examples.

How many kilometres in 20 miles?

$$\frac{20 \times 8}{5} = 32 \text{ kilometres.}$$

How many miles in 50 kilometres?

$$\frac{50 \times 5}{8} = 31\tfrac{1}{4} \text{ miles.}$$

Metres can be turned into yards by remembering that 10 metres are nearly equal to 11 yards.

One *hectare* is rather less than $2\frac{1}{2}$ acres, so that 1 acre is about $\frac{2}{5}$ of a hectare.

One *are* is about the fortieth part of an acre, so that 1 acre is equal to nearly 40 *ares*.

The *litre* is a little more than $1\frac{3}{4}$ pints, and the pint is $\frac{4}{7}$ of a litre.

The gramme is equal to about $15\frac{1}{2}$ grains, thus making the grain the fifteenth part of a gramme.

The kilogramme is nearly equal to 2 English pounds and $\frac{1}{5}$, the English pound being only $\frac{5}{11}$ of a kilogramme.

The French and English tons are practically equal, though the French ton is somewhat lighter, whilst the hundredweight is nearly equal to 51 kilogrammes.

The above are handy for rough-and-ready reckoning, but where accuracy is wanted the tables must be used.

CHAPTER XIII.

MEASURES OF THE METRIC SYSTEM IN ACTUAL USE

The measures which are now going to be briefly described are used wherever the Metric System is obtaining, and with but slight modifications in shape. For their names in some of the principal languages of Europe, a reference to Table II., where they are given in full, with their multiples and sub-multiples, will be necessary.

LINEAR MEASURES

The metre is either a rod or rule, of wood or metal, divided into 10 decimetres, 100 centimetres, and 1,000 millimetres.

For convenience and portability many metres are jointed at each decimetre, so that when folded the metre is a very portable measure. Some of them, made of steel and graduated in the usual way, can easily be carried in a waistcoat pocket, and they are also so pliable that they can be used to measure a circumference very accurately.

The diagram (Fig. V.) represents a decimetre graduated, as usual, in centimetres and millimetres, with a scale of inches placed against it for comparison.

Besides the metre there are also brass measures of 1 decimetre in length. Some of these often contain, inside, another decimetre, and the ends are provided with two little arms, which can be used as callipers. These measures are frequently divided into half millimetres, and they are usually carried by engineers.

Double decimetres are also constructed, as well as half metres and double metres. For land measuring, the decametre,

with its half and double, are the measures in use. These are composed of rods of iron joined together by metallic rings. These measures are chiefly employed by surveyors, architects, and road engineers. Tape measures used by tailors, dressmakers, and others are not legal measures, and cannot therefore be used to measure any quantity of anything intended for sale.

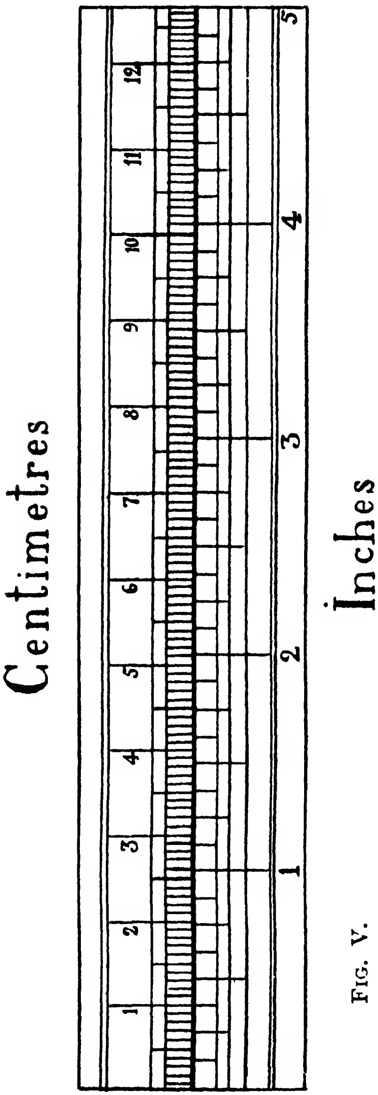


Fig. V.

CUBIC MEASURES AND MEASURES OF CAPACITY

The only cubic measures used are the stere, the double stere, and the half decastere (5 steres). These measures are always built of wood. (Fig. VI.)

The measures of capacity are rather numerous. They are, for

LIQUIDS.

The hectolitre.
,, half hectolitre.
,, double decalitre.
,, decalitre.
,, half decalitre.

These measures are made of copper, cast-iron, or sheet-iron. They are cylindrical, and their depth is equal to the diameter of their base.

LIQUIDS (*continued*).

The double litre.
,, litre.
,, half litre.
,, double decilitre.
,, decilitre.
,, half decilitre.
,, double centilitre.
,, centilitre.

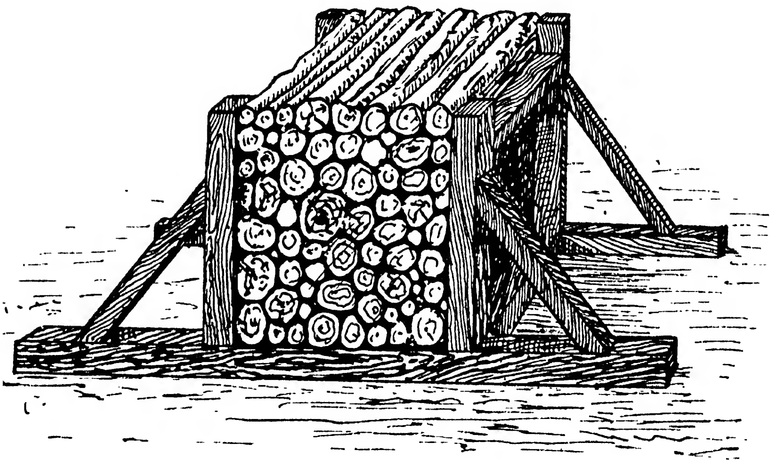


FIG. VI.

These measures are made of pewter, and their depth is double that of the diameter of their base. They are invariably provided with a handle. (See Fig. VII.)

Some of the latter measures are made of tin plate. They are exclusively used for measuring milk and oil. They are also cylindrical, and their depth is equal to the diameter of the base. The oil measures must be distinctly labelled. The latter are not nearly so much used now as in former days, oil, on the Continent, being now generally sold by weight.

The milk measures are not smaller than the half decilitre.

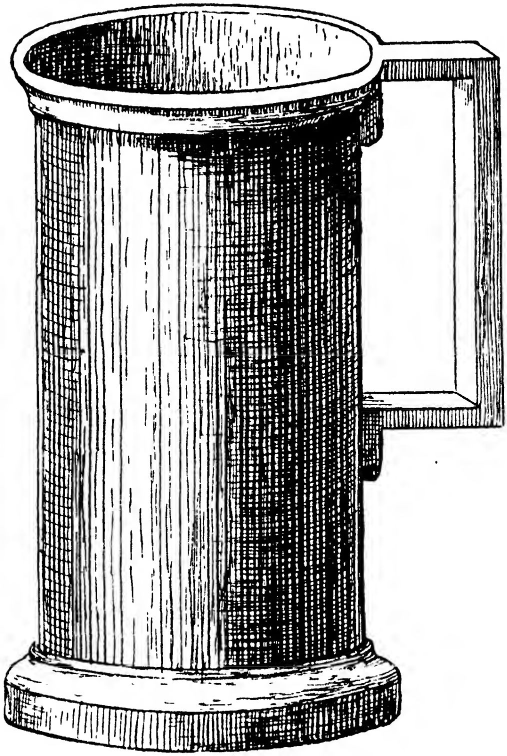


FIG. VII.

DRY MEASURES.

There are eleven such measures:—

The hectolitre.	The litre.
,, half hectolitre.	,, half litre.
,, double decalitre.	,, double decilitre.
,, decalitre.	,, decilitre.
,, half decalitre.	,, half decilitre.
,, double litre.	

These measures, used for grains, seeds, etc., are usually made of oak, strengthened on the outside with pieces of sheet-iron; and so that the height of the measure shall remain constantly the same, the top rim is protected by a piece of

sheet-iron turned over the edge. It is also lawful for such measures to be constructed entirely of sheet-iron or copper, but in such cases the measures must be tinned on the inside. These measures are cylindrical, and their depth is equal to the diameter of the base. (See Fig. VIII.)

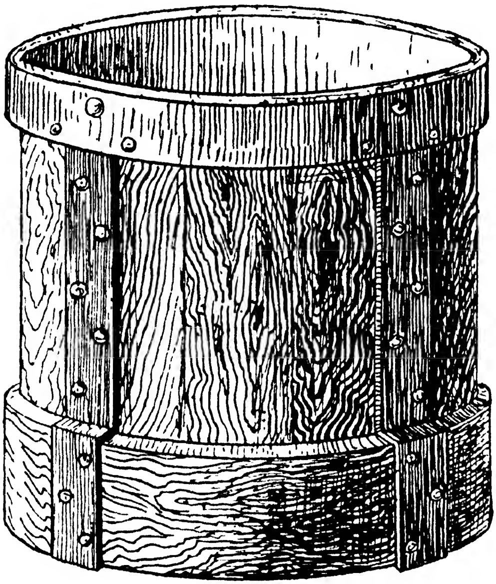


FIG. VIII.

WEIGHTS.

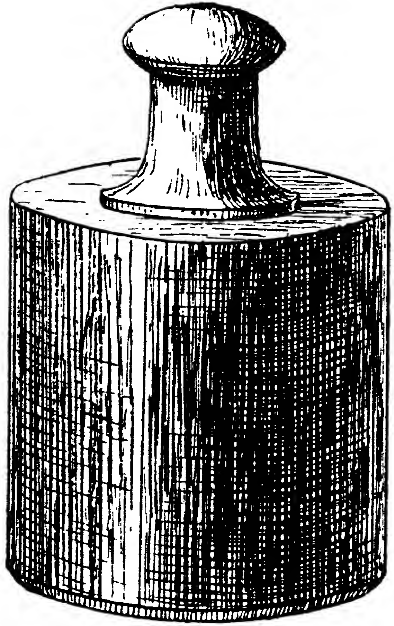
Weights are of two kinds—cast-iron and brass.

Heavy weights are made of cast-iron, and their shape is that of a truncated pyramid with a quadrangular base, and the sides, instead of being sharp, are rounded off. The weight is provided with a ring in the centre, and its weight must be plainly indicated.

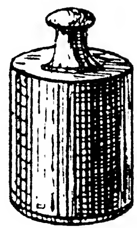
Other weights, also made of cast-iron, are of a different shape. They are truncated pyramids with hexagonal bases.

Brass weights range from 20 kilogrammes to 1 gramme. Brass weights are cylindrical in shape. The cylinder is surmounted by a knob, and the denomination of the weight is

The weight *A* (Fig. IX.) shows a brass weight of half a kilogramme, real size. *B* and *C* are also brass weights, real size, *B* being a weight of 20 grammes, and *C* of 1 gramme.



A



B

C

Fig. IX.

impressed on the top of the brass cylinder. The height of the cylinder itself is equal to the diameter of the base, and the height of the knob is equal to the radius of the base.

Under 200 grammes hollow brass weights are also manufactured. These weights fit into each other. Weights of half a gramme, and under, are usually little square pieces of brass.

The Series of the Various Weights.

Cast-iron Weights.

50 kilogrammes.	1 kilogramme.
20 ,,	½ ,,
10 ,,	2 hectogrammes.
5 ,,	1 hectogramme.
2 ,,	½ ,,

Brass Weights.

20 kilogrammes.	1 hectogramme.
10 ,,	½ ,,
5 ,,	2 decagrammes.
2 ,,	1 decagramme.
1 kilogramme.	½ ,,
½ ,,	2 grammes.
2 hectogrammes.	1 gramme.

Small Brass Weights.

½ gramme.	1 centigramme.
2 decigrammes.	½ ,,
1 decigramme.	2 milligrammes.
½ ,,	1 milligramme.
2 centigrammes.	

All the various weights and measures must bear the name of the maker, or his registered mark. The measures or weights must be inscribed with their proper denominations, and they are further to bear the Government mark, showing that they have been examined by the Inspector of Weights and Measures.

CHAPTER XIV.

METRIC SYSTEM VOCABULARY

Are, from the Latin word *area*—"a surface," is a square decametre, the surface of which is 100 square metres. It is the unit of agrarian or land measure.

Centi expresses a decimal fraction, meaning the hundredth part of the unit to which it is prefixed.

Centiare is the hundredth part of the *are.* It is equal to a square metre; is used to measure small portions of land.

Centigramme, the hundredth part of a gramme; is used mostly to weigh chemicals used for medicinal purposes, and also the precious metals. It is also frequently taken as a unit of weight by scientific men.

Centilitre, the hundredth part of a litre; is used to measure small quantities of liquids, chiefly spirits.

Centime, the hundredth part of a franc. Five centimes are equal to one halfpenny.

Centimetre, the hundredth part of the metre; is often used as a unit in the measurement of short lengths.

Deca, from the Greek word *deka*—"ten," is a word expressing a multiple. It is prefixed to the various units, which it multiplies by 10.

Decagramme, a weight of ten grammes; is very much used in retail trades, especially by grocers.

Decalitre, a measure of capacity, containing 10 litres; is used for both liquid and dry measures.

Decametre, a length of ten metres. It is also the length of the side of the are.

Decastere, ten steres.

Deci expresses a decimal fraction, meaning the hundredth part of the unit to which it is prefixed.

Decigramme, the tenth part of a gramme; is used pretty much the same as the centigramme (*q.v.*).

Decilitre, the tenth part of the litre; is a liquid measure much used in retail trade to measure small quantities of wine, spirits, oil, vinegar.

Decime, the tenth part of the franc. It is equal to 10 centimes, and is practically, though not exactly, equal to the English penny. Though the coin it represents is very much used, the word itself is but seldom heard, ten centimes being usually substituted for it.

Decimetre, the tenth part of a metre; is also the length of the side of the cube containing one litre.

Decistere, the tenth part of a stere (*q.v.*).

Franc, the unit of French money. It is a silver coin of the weight of 5 grammes. It is equal in value to about 9½*d.*

Grammes, from the Greek word *gramma*, which was a Greek weight, the same as the scruple of the Romans. It is the unit of weight, and is the weight of a cubic centimetre of distilled water at its maximum density in a vacuum. As a weight it is mostly used by goldsmiths and apothecaries.

Hectare is used as the unit of land measure for farms, woods, fields. It contains 100 ares or 10,000 square metres. It is equal to a little less than 2½ acres.

Hecto, from the Greek word *hekaton*—"a hundred," is a word expressing a multiple. It is prefixed to the various units, which it multiplies by 100.

Hectogramme, is 100 grammes; is largely used as a weight in retail trades.

Hectolitre, 100 litres. A liquid and dry measure, much used in wholesale trade for measuring wine, spirits, oil, corn, oats, etc.

Hectometre, a length of 100 metres; is equal to the side of the hectare.

Kilo, from the Greek word *chilioi*—"a thousand," is a word expressing a multiple. It is prefixed to the various units, which it multiplies by 1,000.

Kilogramme is the weight of 1,000 grammes. It is also the weight of a cubic decimetre of water. As a weight it is very largely used in business for both wholesale and retail trade.

Kilolitre, a measure of 1,000 litres, not much used.

Kilometre, a length of 1,000 metres. The distances on roads and railways are expressed in kilometres, in most countries in which the Metric System is used.

Litre, from the Greek word *litra*—an old liquid measure used by the Greeks; is now the unit of dry and liquid measures; is much used in retail trade.

Metre, from the Greek word *metron*—"a measure"; is the fundamental unit of the weights and measures of the Metric System; it is the assumed ten-millionth part of the distance from the pole to the equator, and is very much used as a measure in the various trades.

Milli expresses a decimal fraction, meaning the thousandth part of the unit to which it is prefixed.

Milligramme, the thousandth part of the *gramme;* is the weight of a cubic millimetre of water. As a weight, is only used by chemists and scientific men; also in the various mints.

Millimetre, a decimal fraction of the metre equal to its one-thousandth part; is much used in engineering and in fitting work generally.

Myria, from the Greek word *myrioi*—10,000, is a word expressing a multiple. It is prefixed to the various units, which it multiplies by 10,000.

Myriagramme, the weight of 10,000 grammes.

Myriametre, a length of 10,000 metres; is used as the unit of long distances in geography, etc.

Stere, from the Greek word *stereos*—"a solid"; is equal to 1 cubic metre; is used chiefly to measure wood fuel.

CHAPTER XV.

TABLES

TABLE I.

Connection between the various Measures of the Metric System.

ONE of the great beauties of the Metric System is, as we have seen in some of the examples worked out, the wonderful ease with which one measure can be transformed into another. The following brief summary will show at a glance what connection exists between the various measures:—

AREAS.

1	square	metre	=	1 centiare.
1	,,	decametre	=	1 are = 100 square metres.
1	,,	hectometre	=	1 hectare = 100 ares.
1	,,	kilometre	=	100 hectares.
1	,,	myriametre	=	10,000 hectares.

CUBIC MEASURES AND MEASURES OF CAPACITY.

1	cubic	metre	=	1 stere.
10	,,	decimetres	=	1 decalitre.
100	,,	decimetres	=	1 hectolitre.
10	,,	centimetres	=	1 centilitre.
100	,,	centimetres	=	1 decilitre.
1	,,	centimetre	=	1 millilitre.

RELATION BETWEEN THE VOLUME OF WATER AND ITS WEIGHT.

10	cubic	decimetres	of water	weigh	10	kilogrammes.
100	,,	,,	,,	,,	100	,,
1,000	,,	,,	,,	,,	1,000	,,

And 1,000 cubic decimetres of water are equal in volume to 1 cubic metre.

100	cubic	centimetres	of water	weigh	1 hectogramme.
10	”	”	”	”	1 decagramme.
1	”	”	”	”	1 gramme.
100	”	millimetres	”	”	1 decigramme.
10	”	”	”	”	1 centigramme.
1	”	”	”	”	1 milligramme.

1 kilolitre	of water	weighs	1,000	kilogrammes.
1 hectolitre	”	”	100	”
1 decalitre	”	”	10	”
1 decilitre	”	”	1	hectogramme.
1 centilitre	”	”	1	decagramme.

TABLE II.

The names of all the measures of the Metric System and their abbreviations in English, French, German, Italian, and Spanish.

(The abbreviations are between brackets.)

The French, German, Italian, and Spanish articles have been omitted.

ENGLISH.	FRENCH.	GERMAN.	ITALIAN.	SPANISH.
Measures of Length.	*Mesures de Longueur.*	*Längenmasze.*	*Misure di Lunghezza.*	*Medidas de longitud.*
Myriametre (Mm.)	Myriamètre (Mm.)		Miriametro (Mm.)	Miriámetro (Mm.)
Kilometre (Km.)	Kilomètre (Km.)	Kilometer (*Km.*)	Chilometro (Cm.)	Kilómetro (Km.)
Hectometre (Hm.)	Hectomètre (Hm.)		Ettometro (Em.)	Hectómetro (Hm.)
Decametre (Dm.)	Décamètre (Dm.)	Dekamtr. (*Dm.*) or Kette	Decametro (Dm.)	Decámetro (Dm.)
Metre (*m.*)	**Metre** (*m.*)	**Meter** (*m.*) or Stab	**metro** (*m.*)	**metro** (*m.*)
Decimetre (*dm.*)	Dècimètre (*dm.*)	Dezimeter (*dm.*)	decimetro (*dm.*)	decímetro (*dm.*)
Centimetre (*cm.*)	Centimètre (*cm.*)	Zentimtr. (*cm.*) or Neuzoll	centimetro (*cm.*)	centímetro (*cm.*)
Millimetre (*mm.*)	Millimètre (*mm.*)	Millimtr. (*mm.*) or Strich	millimetro (*mm.*)	milímetro (*mm.*)
Square Measures.	*Mesures de Superficie.*	*Flächenmasze.*	*Misure di Superficie.*	*Medidas de Superficie.*
Sq. myriametre (Mm.^{2})	Myriamètre carré (Mmq.)		Miriametro quad'to (Mm.^{2})	Miriámetro cuad'do (Mm.^{2})
Sq. kilometre (Km.^{2})	Kilomètre carré (Kmq.)		Chilometroquadrato (Cm.^{2})	Kilómetro cuadrado (Km.^{2})
Sq. hectometre (Hm.^{2})	Hectomètre carré (Hmq.)		Ettometro quadrato (Em.^{2})	Hectometro cuad'do (Hm.^{2})
Sq. decametre (Dm.^{2})	Décamètre carré (Dmq.)		Decametro quad'to (Dm.^{2})	Decámetro cuad'do (Dm.^{2})
Sq. metre (*m.*^{2})	**mètre carré** (*mq.*)	**Quadratmeter** (*qm.*)	**metro quadrato** (*m.*^{2})	**metro cuadrado** (*m*^{2}.)
Sq. decimetre (*dm.*^{2})	décimetre carré (*dmq.*)	Quadratdezimeter (*qdm.*)	decimetro quadrato (*dm.*^{2})	decímetro cuadrado (*dm.*^{2})
Sq. centimetre (*cm.*^{2})	centimètre carré (*cmq.*)	Quadratzentimeter (*qcm.*)	centimetro quadrato (*cm.*^{2})	centímetro cuadrado (*cm.*^{2})
Sq. millimetre (*mm.*^{2})	millimètre carré (*mmq.*)	Quadratmillimetr. (*qmm.*)	millimetro quadrato (*mm.*^{2})	milímetro cuadrado (*mm.*^{2})
Land Measures.	*Mesures Agraires.*		*Misure Agrarie.*	*Medidas Agrarias.*
hectare (H.)	hectare (*ha.*)	Hektar (*ha.*)	ettara (Ea.)	hectárea (Ha.)
are (*a.*)	**are** (*a.*)	**Ar** (*a.*)	**ara** (*a.*)	**area** (*a.*)
centiare (*c.*)	centiare (*ca.*)		centiara (*ca.*)	centiárea (*ca.*)

Cubic Measures.	*Mesures de Volume.*	*Körper und Hohlmasze.*	*Misure di Volume.*	*Medidas de Volumen.*
cubic metre (m.^{3})	mètre cube (*mc.*)	**Kubikmeter** (*cbm.* or *c.'*)	**metro cubo** (*m^3.*)	**metro cúbico** (*m.^{3}*)
cubic decimetre (dm.^{3})	décimètre cube (*dmc.*)	Kubikdezimeter (*cdm.* or *c."*)	decimetro cubo (*dm.^{3}*)	decimetro cúbico (*dm.^{3}*)
cubic centimetre (cm.^{3})	centimètre cube (*cmc.*)	Kubikzentimeter (*ccm.* or c.''')	centimetro cubo (*cm.^{3}*)	centimetro cúbico (*cm.^{3}*)
cubic millimetre (mm.)	millimètre (*mmc.*)	Kubikmillimeter (*cmm.* or *c.""*)	millimetro cubo (*mm.^{3}*)	milimetro cúbico (*mm.^{3}*)
decastere (Ds.)	décastère (Dst.)		decastero (Ds.)	Decasterio (Ds.)
stere (*st.*)	**stère** (*st.*)		stero (*st.*)	Estério (*st.*)
decistere (*ds.*)	décistère (*dst.*)		decistero (*ds.*)	Decisterio (ds.)
Measures of Capacity.	*Mesures de Capacité.*		*Misure di Capacita.*	*Medidas de Capacidad.*
Kilolitre (Kl.)	Kilolitre (Kl.)	Hektoliter (*hl.*) or Fasz	Chilolitro (Cl.)	Kilolitro (Kl.)
Hectolitre (Hl.)	Hectolitre (Hl.)	½ Hektoliter or Neuscheffel (Nsch.)	Ettolitro (El.)	Hectolitro (Hl.)
Decalitre (Dl.)	Décalitre (Dl.)		Decalitro (Dl.)	Decalitro (Dl.)
Litre (*l.*)	**Litre** (*l.*)	**Liter** (*l.*) or Kanne	**litro** (*l.*)	**litro** (*l.*)
decilitre (*dl.*)	décilitre (*dl.*)	½ Liter or Schoppen (Sch.)	decilitro (*dl.*)	decilitro (*dl.*)
centilitre (*cl.*)	centilitre (*cl.*)		centilitro (*cl.*)	centilitro (*cl.*)
Measures of Weight.	*Mesures de Poids.*	*Gewichte.*	*Misure di Peso.*	*Medidas de Peso.*
Myriagramme (Mg.)	Myriagramme (Mg.)	Kilogramm (Kg.)	Miriagramma (Mg.)	Miriagramo (Mg.)
Kilogramme (Kg.)	Kilogramme (Kg.)	½ Kilogramm or Pfund ℔.	Chilogramma (Cg.)	Kilogramo (Kg.)
Hectogramme (Hg.)	Hectogramme (Hg.)	Dekagramm (dkg.) or Neulot (nlt.)	Ettogramma (Eg.)	Hectogramo (Hg.)
Decagramme (Dg.)	Décagramme (Dg.)		decagramma (Dg.)	decagramo (Dg.)
Gramme (*g.*)	**Gramme** (*g.*)	**Gramm** (g.)	gramma (*gr.*)	gramo (*g.*)
Decigramme (*dg.*)	Décigramme (*dg.*)	Dezigramm (dg.)	decigramma (*dg.*)	decigramo (*dg.*)
Centigramme (*cg.*)	Centigramme (*cg.*)	Zentigramm (cg.)	centigramma (*cg.*)	centigramo (*cg.*)
Milligramme (*mg.*)	Milligramme (*mg.*)	Milligramm (mg.)	milligramma (*mg.*)	miligramo (*mg.*)
Metric cwt. (Mc.)	Le Quintal (Qu.)	Zentner (C$^{tr.}$)	él quintale metrico (Qu.)	el quintal metrico (Qm.)
Metric ton (Tm.)	La Tonne (Ton.)	Tonne (t.)	la tonnellata (Tonn.)	la tonelada (T.)
Coinage.	*Monnaies.*	*Die Markwährung.*	*Monete.*	*Monedas.*
Pound	**Franc** (F. or f.)	Mark (M.)	**lira**	**peseta**
Florin	Décime	Pfennige (Pf.)		
Cent (?)	Centime (*c.*)		centesimo	céntimo
Mil (?)				

TABLE III.

Measures of Length.

		Inches.		Feet.		Yards.
Millimetre	=	0·03937	...	0·003281	...	0·0010936
Centimetre	=	0·39371	...	0·032809	...	0·0109363
Decimetre	=	3·93708	...	0·328090	...	0·1093633
Metre	=	39·37079	...	3·280989	...	1·0936331
Decametre	=	393·70790	...	32·809892	...	10·9363306
Hectometre	=	3937·07900	...	328·089917	...	109·3633056
Kilometre	=	39370·79000	...	3280·899167	...	1093·6330556
Myriametre	=	393707·90000	...	32808·991667	...	10936·3305556

Cubic, or Measures of Capacity.

		Cubic inches.	Cubic feet.	Pints.	Gallons.	Bushels.
Millilitre, or cubic centimetre	=	0·06103 ...	0·000035 ...	0·00176 ...	0·0002201 ...	0·0000275
Centilitre, 10 cubic do.	=	0·61027 ...	0·000353 ...	0·01761 ...	0·0022010 ...	0·0002751
Decilitre, 100 cubic do.	=	6·10271 ...	0·003532 ...	0·17608 ...	0·0220097 ...	0·0027512
Litre, or cubic decimetre	=	61·02705 ...	0·035317 ...	1·76077 ...	0.2200967 ...	0·0275121
Decalitre	=	610·27052 ...	0·353166 ...	17·50773 ...	2·2009668 ...	0·2751208
Hectolitre	=	6102·70515 ...	3·531658 ...	176·07734 ...	22·0096677 ...	2·7512085
Kilolitre	=	61027·05152 ...	35·316581 ...	1760·77341 ...	220·0966767 ...	27·5120846
Myrialitre	=	610270·51519 ...	353·165807 ...	17607·73414 ...	2200·9667675 ...	275·1208459

TABLE V.

For the Conversion of English Weights and Measures into the Metric System.

Measures of Length.

Inch	=	0·02549 metres
Foot	=	0·30479 ,,
Yard	=	0·91438 ,,
Fathom	=	1·82877 ,,
Pole or Perch ($5\frac{1}{2}$ yards)	=	5·02911 ,,
Furlong (220 yards)	=	201·16437 ,,
Mile (1,760 yards)	=	1609·31 ,,

Square Measures.

Yard	=	0·83610 square metres.
Rod	=	25·29194 ,, ,,
Rood (1,210 square yards)	=	10·11677 ,, ,,
Acre (4,840 square yards)	=	0·40467 hectare.

Cubic Measures.

Pint ($\frac{1}{8}$ of gallon)	=	0·5679 litre.
Quart ($\frac{1}{4}$ of gallon)	=	1·1359 ,,
Imperial Gallon	=	4·543468 ,,
Peck (2 gallons)	=	9·086916 ,,
Bushel (8 gallons)	=	36·34766 ,,
Sack (3 bushels)	=	1·09043 hectolitre.
Quarter (8 bushels)	=	2·90781 ,,
Chaldron (12 sacks)	=	13·08516 ,,

Weights.

Troy.	Grain ($\frac{1}{24}$ dwt.)	=	6·479895 centigrammes.
	Pennyweight ($\frac{1}{20}$ oz.)	=	1·555175 gramme.
	Ounce ($\frac{1}{12}$ lb. troy)	=	31·103496 ,,
	Pound (5,760 grs.)	=	373·241948 ,,
Avoirdupois.	Dram ($\frac{1}{16}$ oz.)	=	1·771846 ,,
	Ounce	=	28·349540 ,,
	Pound (7,000 grs.)	=	453·592645 ,,
	Cwt. (112 lbs.)	=	50·802 kilogrammes.
	Ton (20 cwt.)	=	1016·048 ,,

TABLE VI.

English Coins and Banknotes.

GOLD.

	frcs.	cts.		frcs.	cts.
Sovereign, £1	25 ·	22*	Half-sovereign, 10*s.* ...	12 .	61

SILVER.

	frcs.	cts.		frcs.	cts.
Crown, 5*s.*	6 ·	30	Sixpence, 6*d.*	0 ·	63
Half-crown, 2*s.* 6*d.*......	3 ·	15	Fourpence, 4*d.*	0 ·	42
Florin, 2*s.*	2 ·	52	Threepence, 3*d.*	0 ·	315
Shilling, 1*s.*	1 ·	26			

COPPER.

	frcs.	cts.		frcs.	cts.
Penny, 1*d.*, nearly	0 ·	10	Farthing, $\frac{1}{4}$*d.*	0 ·	025
Half-penny, $\frac{1}{2}$*d.*	0 ·	05			

NOTES.

	frcs.	cts.		frcs.	cts.
£5	126 ·	10	£100, a little over ...	2522 ·	00
£10	252 ·	20	£1000 ,, ...	25220 ·	00
£50	1261 ·	00			

French Coins and Banknotes.

GOLD.

	£	s.	d.		£	s.	d.
Pièce de 100 frcs.	3	19	$4\frac{1}{2}$†	Pièce de 20 frcs.	0	15	$10\frac{1}{2}$
,, 50 ,, ...	1	19	$8\frac{1}{4}$†	,, 10 ,, ...	0	7	$11\frac{1}{4}$
,, 40 ,, ...	1	11	9 †	,, 5 ,, ...	0	3	$11\frac{5}{8}$†

SILVER.

	£	s.	d.		£	s.	d.
Pièce de 5 frcs.	0	3	$11\frac{5}{8}$	Pièce de 1 frc.	0	0	$9\frac{3}{4}$
,, 2 ,, ...	0	1	$7\frac{1}{2}$	,, 0·50 ,, ...	0	0	$4\frac{3}{4}$

COPPER.

	£	s.	d.		£	s.	d.
10 centimes, nearly	0	0	1	2 centimes	0	0	·2
5 ,, ,, ...	0	0	$0\frac{1}{2}$	1 ,, ...	0	0	·1

NOTES.

	£	s.	d.		£	s.	d.
50 frcs.	1	19	$8\frac{1}{4}$	500 frcs.	19	16	$10\frac{1}{2}$
100 ,, ...	3	19	$4\frac{1}{2}$	1000 ,, ...	39	13	9
200 ,, ...	7	18	9				

* When changing English money into French or German, it is well to bear in mind that the rate of exchange is nearly always in favour of English money. The sovereign frequently fetches 25.25 frcs., and even as much as 25·37 frcs. (See page 84.)

† Scarcely ever seen.

German Coins and Banknotes.

GOLD.

Doppelkrone	= 20 marks	= 19*s.* 7*d.*	nearly.
Krone	= 10 ,,	= 9*s.* 9½*d.*	,,
½ krone	= 5 ,,	= 4*s.* 10¾*d.*	,,

SILVER.

5 markstück	= 5 marks	= 4*s.* 10¾*d.*	nearly.
2 ,,	= 2 ,,	= 1*s.* 11½*d.*	,,
1 ,,	= 1 ,,	= 11¾d.	,,
50 pfennigstück	= ½ mark	= 5⅞*d.*	,,

NICKEL.

20 pfennigstück	= 0·20 pfennige	= 2¾*d.*	nearly.
10 ,,	= 0·10 ,,	= 4.7	farthings.
5 ,,	= 0·05 ,,	= 2·35	,,

COPPER.

2 pfennigstück	= 0·02 pfennige	= nearly a farthing.
1 ,,	= 0·01 pfennig	= half a farthing.

BANKNOTES.

1,000 marks	= £48 19*s.* 2*d.*
100 ,,	= £4 17*s.* 11*d.*

EXCHEQUER NOTES.

50 marks	= £2 8*s.* 11½*d.*
20 ,,	= 19*s.* 7*d.* nearly.
5 ,,	= 4*s.* 10¾*d.*

The Mint par between England, France, and Germany is as hereunder :—

£1 = 25·22 francs = 20·42945 marks.
20-franc piece = 15*s.* 10½*d.* = 16·2128 marks nearly.
20 marks = 19*s.* 6·95*d.* = 24·69 francs.

N.B.—The above equivalent values are those at par, and they are given without any regard to the fluctuations of the exchange.

TABLE VII.

Decimal Parts of a Year.

Days.	Decimal Part of a Year.	Days.	Decimal Part of a Year.	Days.	Decimal Part of a Year.
1	0·0027	42	0·1151	83	0·2274
2	0·0055	43	0·1178	84	0·2301
3	0·0082	44	0·1205	85	0·2329
4	0·011	45	0·1233	86	0·2356
5	0·0137	46	0·126	87	0·2384
6	0·0164	47	0·1288	88	0·2411
7	0·0192	48	0·1315	89	0·2438
8	0·0219	49	0·1342	90	0·2466
9	0·0247	50	0·137	91	0·2493
10	0·0274	51	0·1397	92	0·2521
11	0·0301	52	0·1425	93	0·2548
12	0·0329	53	0·1452	94	0·2575
13	0·0356	54	0·1479	95	0·2603
14	0·0384	55	0·1507	96	0·263
15	0·041	56	0·1534	97	0·2658
16	0·0438	57	0·1562	98	0·2685
17	0·0466	58	0·1589	99	0·2712
18	0·0493	59	0·1616	100	0·274
19	0·052	60	0·1644	101	0·2767
20	0·0548	61	0·1671	102	0·2795
21	0·0575	62	0·1699	103	0·2822
22	0·0603	63	0·1726	104	0·2849
23	0·063	64	0·1753	105	0·2877
24	0·0658	65	0·1781	106	0·2904
25	0·0685	66	0·1808	107	0·2932
26	0·0712	67	0·1836	108	0·2959
27	0·074	68	0·1863	109	0·2986
28	0·0767	69	0·189	110	0·3014
29	0·0795	70	0·1918	111	0 3041
30	0·0822	71	0·1945	112	0·3068
31	0·0849	72	0·1973	113	0·3096
32	0·0877	73	0·2	114	0·3123
33	0·0904	74	0·2027	115	0·3151
34	0·0932	75	0·2055	116	0·3178
35	0·0959	76	0·2082	117	0·3205
36	0·0986	77	0·211	118	0·3233
37	0·1014	78	0·2137	119	0·326
38	0·1041	79	0·2164	120	0·3288
39	0·1068	80	0·2192	121	0·3315
40	0·1096	81	0·2219	122	0·3342
41	0·1123	82	0·2247	123	0·337

Days.	Decimal Part of a Year.	Days.	Decimal Part of a Year.	Days.	Decimal Part of a Year.
124	0·3397	173	0·474	222	0·6082
125	0·3425	174	0·4768	223	0·611
126	0·3452	175	0·4795	224	0·6137
127	0·3479	176	0·4822	225	0·6164
128	0·3507	177	0·4849	226	0·6192
129	0·3534	178	0·4877	227	0·6219
130	0·3562	179	0·4904	228	0·6247
131	0·3589	180	0·4932	229	0·6274
132	0·3616	181	0·4959	230	0·6301
133	0·3644	182	0·4986	231	0·6329
134	0·3671	183	0·5014	232	0·6356
135	0·3699	184	0·5041	233	0·6384
136	0·3726	185	0·5068	234	0·6411
137	0·3753	186	0·5096	235	0·6438
138	0·3781	187	0·5123	236	0·6466
139	0.3808	188	0·5151	237	0·6493
140	0·3836	189	0·5178	238	0·6521
141	0·3863	190	0·5205	239	0·6548
142	0·389	191	0·5233	240	0·6575
143	0·3918	192	0·526	241	0·6602
144	0·3945	193	0·5288	242	0·663
145	0·3973	194	0·5315	243	0·6658
146	0·4	195	0·5342	244	0·6685
147	0·4027	196	0·537	245	0·6712
148	0·4055	197	0·5397	246	0·674
149	0·4082	198	0·5425	247	0·6767
150	0·411	199	0·5452	248	0·6795
151	0·4137	200	0·548	249	0·6822
152	0·4164	201	0·5506	250	0·6849
153	0·4192	202	0·5534	251	0·6877
154	0·4219	203	0·5562	252	0·6904
155	0·4247	204	0·5589	253	0·6932
156	0·4274	205	0·5616	254	0·6959
157	0·4301	206	0·5644	255	0·6986
158	0·4329	207	0·5671	256	0·7014
159	0·4356	208	0·5699	257	0·7041
160	0·4384	209	0·5726	258	0·7068
161	0·4411	210	0·5753	259	0·7096
162	0·4438	211	0·5784	260	0·7123
163	0·4466	212	0·5808	261	0·7151
164	0·4493	213	0·5836	262	0·7178
165	0·4521	214	0·5863	263	0·7205
166	0·4548	215	0·589	264	0·7233
167	0·4575	216	0·5918	265	0·726
168	0·4603	217	0·5945	266	0·7288
169	0·463	218	0·5973	267	0·7315
170	0·4658	219	0·6	268	0·7342
171	0·4685	220	0·6027	269	0·737
172	0·4712	221	0·6055	270	0·7397

Days.	Decimal Part of a Year.	Days.	Decimal Part of a Year.	Days.	Decimal Part of a Year.
271	0·7425	303	0·8301	335	0·9178
272	0·7452	304	0·8329	336	0·9205
273	0·7479	305	0·8356	337	0·9233
274	0·7507	306	0·8384	338	0·926
275	0·7534	307	0·8411	339	0·9288
276	0·7562	308	0·8438	340	0·9315
277	0·7589	309	0·8466	341	0·9342
278	0·7616	310	0 8493	342	0·9370
279	0·7644	311	0·8521	343	0·9397
280	0·7671	312	0·8548	344	0·9425
281	0·7699	313	0·8575	345	0·9452
282	0·7726	314	0·8603	346	0·9479
283	0·7753	315	0·863	347	0·9507
284	0·7781	316	0 8658	348	0·9534
285	0·7808	317	0·8685	349	0·9562
286	0·7836	318	0·8712	350	0·9589
287	0·7863	319	0·874	351	0·9616
288	0·789	320	0·8767	352	0·9644
289	0·7918	321	0·8795	353	0·9671
290	0·7945	322	0·8822	354	0·9699
291	0·7973	323	0·8849	355	0·9726
292	0·8	324	0·8877	356	0·9753
293	0·8027	325	0·8904	357	0·9781
294	0·8055	326	0·8932	358	0·9808
295	0.8082	327	0·8959	359	0·9836
296	0·811	328	0·8986	360	0·9863
297	0·8137	329	0·9014	361	0·989
298	0·8164	330	0·9041	362	0·9918
299	0·8192	331	0·9068	363	0·9945
300	0·8219	332	0·9096	364	0·9973
301	0·8247	333	0·9123	365	1
302	0·8274	334	0·9151		

APPENDIX

PROBLEMS

EXERCISES ON CHAPTER III.

1. Write: (1) 7 tenths; (2) 7 hundredths; (3) 7 millionths; (4) 33 units and 27 thousandths; (5) 327 hundredths: (6) 73 tenths; (7) 827 ten-thousandths; (8) 7 units and 4 thousandths; (9) 337,475 thousandths; (10) 1,000 thousandths.

2. Read: (1) 3·75; (2) 22·075; (3) 637·004; (4) 0·02; (5) 0·00789; (6) 275·32140; (7) 0·0003; (8) 17·08; (9) 200·075; (10) 5·070203?

3. Multiply each of the numbers in Question 2, first by 10, then by 1,000, and divide the same numbers by 100 and 10,000.

4. What is the difference between (1) 0·2 and 0·02; (2) 0·2 and 0·20; (3) 3·4 and 3·004; (4) 0·50 and 0·05; and (5) 75·075 and 75075?

5. Add together—
 (1) 34·03 + 75·027 + 0·999 + 789·98 + 1712·3456 + 0·000789;
 (2) 0·000392 + 0·0001 + 274·59983 + 103·288 + 73·04056008.

6. From (1) 12374·031 subtract 2799·7893;
 „ (2) 2345·678 „ 299·98902;
 „ (3) 3896·0381 „ 2785·949921;
 „ (4) 224 „ 223·99999;
 „ (5) 1 „ 0·9999999.

7. Multiply: (1) 35·407 by 12·54;
 „ (2) 4·0567 „ 9·503;
 „ (3) 4·0015 „ 29;
 „ (4) 0·03054 „ 0·023;
 „ (5) 12·34567 „ 3·5847;
 „ (6) 0·00001 „ 100,000;
 „ (7) 2·003 „ 0·0024;
 „ (8) 72·0001 „ 2·002;
 „ (9) 0·0001 „ 0·00002;
 „ (10) 100 „ 0·000001.

The above should also be worked according to the contracted method.

8. Divide : (1) 23·41005 by 7·9863 ;
„ (2) 123·45 „ 100 ;
„ (3) 357·6543 „ 13·18616 ;
„ (4) 0·089 „ 0·09876 ;
„ (5) 17·0146 „ 3·53 ;
„ (6) 0·000064 „ 0·61234 ;
„ (7) 437·4825 „ 56 ;
„ (8) 340·5067 „ 39 ;
„ (9) 0·004736 „ 0·034 ;
„ (10) 294 „ 7·356.

The above should also be worked according to the contracted method.

9. Reduce to decimals the following vulgar fractions : (1) $\frac{1}{2}$; (2) $\frac{2}{3}$; (3) $\frac{3}{4}$; (4) $\frac{5}{6}$; (5) $\frac{7}{8}$; (6) $\frac{9}{11}$; (7) $\frac{23}{74}$; (8) $\frac{201}{387}$; (9) $2\frac{3}{11}$; (10) $7\frac{4}{7}$; and, when possible, carry the denominator to at least six or seven places of decimals.

10. Transform the following circulating decimals into vulgar fractions : (1) $0{\cdot}\dot{1}3\dot{5}$; (2) $0{\cdot}\dot{7}6923\dot{0}$; (3) $4{\cdot}\dot{1}6\dot{2}$; (4) $0{\cdot}\dot{3}$; (5) $0{\cdot}\dot{9}$; (6) $0{\cdot}\dot{3}\dot{6}$; (7) $0{\cdot}2\dot{7}$; (8) $0{\cdot}5\dot{3}$; (9) $0{\cdot}5\dot{9}2\dot{5}$; (10) $0{\cdot}31\dot{9}30\dot{6}$.

EXERCISES ON CHAPTER IV.

1. Write in figures and add together—

(1) 3 hectos, 4 decas, 5 units, 8 kilos, 7 decis ;
(2) 7 kilos, 17 decas, 23 hectos, 75 millis ;
(3) 7 decis, 23 centis, 15 kilos, 2 myrias ;
(4) 27 myrias, 15 units, 2 decis, 15 centis ;
(5) 10 hectos, 20 decas, 25 decis ;

2. Express—

(1) 23 kilos as decis ;
(2) 7 myrias as (*a*) hectos and (*b*) centis ;
(3) 14 kilos as (*a*) millis and (*b*) decas ;
(4) 73,000 millis as units ;
(5) 1,234,567 centis as (*a*) decas, (*b*) hectos, (*c*) kilos.

3. (1) How many kilos in 1 myria ?
(2) „ „ centis in 1 hecto ?
(3) „ „ millis in 1 myria ?
(4) „ „ millis in 1 kilo ?
(5) „ „ centis in 1 deca ?

4. (1) What part of a kilo is a deci?
(2) „ „ „ myria „ milli?
(3) „ „ „ deca „ deci?
(4) „ „ „ centi „ milli?
(5) „ „ „ hecto „ centi?

EXERCISES ON CHAPTER V.

PART I.

1. Read the following: (1) 1·111 metres; (2) 2·022 metres; (3) 3·003 metres; (4) 0·001 metre; and (5) 0·50 metre.

2. Read 13567 metres, using the kilometre as unit.

3. Write in figures: (1) 1 centimetre; (2) 4 millimetres; (3) 5 decimetres; (4) 17 hectometres and 7 metres; and (5) 3 metres and a quarter.

4. Write in figures: (1) 18 kilometres and a quarter; (2) 6 metres and a half; (3) half a decimetre; (4) a quarter of a decimetre; and (5) half a millimetre.

5. Add together: 5·15 metres + 85 centimetres + 2 metres + 2 decimetres + 1 metre and three quarters.

6. From 18 metres and 95 centimetres subtract 9 metres and 97 centimetres.

7. Multiply 17 metres and 15 millimetres by 0·725. Only three decimals wanted, so use contracted multiplication.

8. Multiply 12 kilometres and a quarter by 0·75.

9. Divide 12,345 metres by 54.

10. Divide 234 kilometres and a half by 32.

PART II.

1. How many metres are there in four pieces of calico measuring respectively: 75 metres, 92 metres, 22 metres and 5 decimetres, and 101 metres and a half?

2. If a man can walk 21 metres in 10 seconds, how many metres will he be able to walk in 12 minutes at the same rate?

3. What is the difference between 23 kilometres and 2 myriametres 3 kilometres?

4. What is the distance, in kilometres, etc., between two towns, if the total length is composed of the following measurements: 4 myriametres, 23 hectometres, 6 myriametres, 30 hectometres, 7 myriametres, 2 hectometres, 5 decametres, and 13 metres?

5. A man having to walk 1,255 kilometres and 3 hectometres in a certain time, gave up after he had travelled 1,105 kilometres and 2 hectometres. How much had he to travel to complete the whole distance?

6. A merchant sold, in the course of a year, 3,785 pieces of cloth, containing on an average 74 metres each. How many metres did he sell?

7. In a factory 275 workmen have worked 282 days. How many metres of velvet have they manufactured if on an average each man can manufacture 2·45 metres per day?

8. What is the height of a flight of steps composed of 24 steps each 195 millimetres high?

9. If 7,869 pieces of linen contain 344,268·75 metres, what is the length of each piece?

10. The height of a tower which is reached by 325 steps is 48·75 metres. What is the height of each step, assuming that they reach to the very top?

Exercises on Chapter VI.

Part I.

1. Read the following: (1) 27·72 square metres; (2) 0·03 square metre; (3) 0·000029 square metre; (4) 5·207 square metres; (5) 0·5 square metre.

2. Write in figures: (1) 1 square centimetre; (2) 7 square millimetres; (3) 192 square centimetres; (4) half a square metre; (5) half a square decimetre.

3. Write in figures and add together: 3 square metres and 73 square decimetres + 17 square centimetres + 7 square metres and 27 square decimetres + 172 square metres and three-quarters.

4. Subtract 48·720234 square metres from 49 square metres.

5. What is the difference between:

(*a*) $\frac{2}{10}$ of a square metre and 2 square decimetres?
(*b*) $\frac{3}{100}$ " " 3 " centimetres?

6. Multiply 0·01234 square metres by 321456, and read the result.

7. Multiply 27·0215 square metres by (*a*) 10 and also by (*b*) 1,000, and read the result.

8. Divide 62·7899 square metres by (*a*) 10, also (*b*) by 100, and read the result.

9. The product 0·061152 square millimetres has 0·78 for one of its factors. Find the other factor.

10. If there are 32,970 square metres in 52 areas, what is the area of each?

Part II.

1. The product of two numbers is 23·40 square metres. If one of them is 5, what is the other?

2. The area of a courtyard is 746·50 square metres. There is in it a lawn covering 678·85 square metres. What is the difference between the two areas?

3. What is the total area of 12 walls, each measuring 17·75m. by 3·85m.?

4. How many square metres of carpet will be required to carpet three rooms, measuring the one 5·15m. by 4·25m., the second 4·45m. by 3·18m., and the third 3·80m. by 2·95m.?

5. How many square metres of glass will be required to glaze 13 windows, each containing 8 panes, if each pane measures 0·55m. by 0·37m.?

Exercises on Chapter VI.

1. Read: (1) 15·0237 hectares; (2) 27·8145 hectares; (3) 179·07 ares; (4) 218·97 ares; (5) 1,119·5 hectares.

2. Write in figures: (1) 2 hectares 15 ares 17 centiares; (2) 12 ares 99 centiares; (3) 8 hectares 3 centiares; (4) 2 hectares 199 centiares; (5) 5 ares 5 centiares; (6) 128 ares 9 centiares; (7) 1,500 ares 27 centiares; (8) 106 hectares 11 ares; (9) 227 ares 3 centiares; (10) 27,000 hectares 97 centiares.

3. Write in figures and add together: 12 hectares 20 ares 15 centiares + 17 ares 2 centiares + 317 ares 27 centiares + 112 centiares.

4. How many hectares, etc., are there in each of the following numbers: (1) 100 ares; (2) 1,927 ares; (3) 21,178 centiares; (4) 200,304 centiares; (5) 2,345,678 centiares; (6) 2,345,678 ares?

5. How many centiares are there in: (1) 1 hectare; (2) 27 ares; (3) 1,127 ares; (4) 234 hectares; (5) 12,345 ares?

6. How many ares are there in four plots of land containing (*a*) 97 ares 2 centiares; (*b*) 79 ares 17 centiares; (*c*) 42 ares 25 centiares; (*d*) 3 hectares 97 centiares?

7. If on an estate containing 789 hectares there is a wood of 12 hectares 27 ares 92 centiares, what remains in arable land or meadows?

8. If 23 plots of land contain each 4 hectares 5 ares 15 centiares, what is the total area?

9. A forest is divided into 53 portions, each of which covers 8 hectares 9 ares 99 centiares. What is the total area covered by it?

10. Eight persons want to divide among themselves an estate containing 1,884 hectares 88 ares 80 centiares. Find the share of each.

Exercises on Chapter VII.

1. Read: (1) 15·631213 cubic metres; (2) 0·003667 cubic metres; (3) 3·001234567 cubic metres; (4) 0·000000007 cubic metres; (5) 77·3 cubic metres; (6) 21·0234 cubic metres; (7) 0·01 cubic metres.

2. Write in figures: (1) 3 cubic metres 75 cubic decimetres; (2) 73 cubic metres 793 cubic centimetres; (3) 212 cubic millimetres; (4) 2 cubic decimetres and a half; (5) half a cubic metre; (6) half a cubic centimetre.

3. Four blocks of stone contain respectively 798,234 cubic centimetres, 378 cubic decimetres, 789,345,216 cubic millimetres, and 1 cubic metre and three-quarters. How many cubic metres, etc., in the whole?

4. What is the difference between the contents of two cisterns, one of which contains 2·023005 cubic metres, and the other 978,007 cubic centimetres?

5. If 3,780 freestones, each measuring 325 cubic decimetres, have been used in a building, find the total number of cubic metres, etc., of stone used in that building.

6. A wall containing 163·58106 cubic metres has been built with bricks 0·002260 cubic metres. How many bricks have been used?

7. How many steres of wood have been burnt in four fireplaces if they burnt respectively 17 decisteres, 2 steres and a quarter, 1·6 steres, and 18·7 steres?

8. Divide 4,788,855 steres of wood into 27 lots, and say how much in each.

9. If a pile of wood has been divided among 86 persons, and each received 7 decisteres, how many steres were there in the whole pile?

10. A landowner had 247 trees felled which produced 617 steres of wood. How much is that on an average for each tree?

EXERCISES ON CHAPTER VII.

1. How many litres are there in: (1) 28 hectolitres; (2) 5 decalitres; (3) 127 centilitres; (4) 3,724 centilitres; (5) 9 hectolitres 6 decalitres; (6) 15 decalitres 175 centilitres?

2. How many decalitres are there in: (1) 2,734 centilitres; (2) 273 litres; (3) 7 hectolitres; (4) 3,245 decilitres?

3. Add together 3 hectolitres 75 litres; 2 hectolitres 75 litres; 5 hectolitres 2 decalitres 7 litres; 292 decilitres; 3,712 centilitres.

4. How many litres are contained in 9,685 flasks, if each one contains 25 centilitres?

5. How many hectolitres of oats are contained in 6,749 sacks, if each one contains 1 hectolitre 8 decilitres?

6. How many hectolitres of wine are there in 768 casks, if each cask contains 2 hectolitres 85 litres?

7. If in a cellar there are 945 hectolitres of wine, and each cask contains 2 hectolitres 25 litres, how many casks are there in it?

8. A man has to carry to a granary 790 hectolitres 5 decalitres of oats; if he carries 1 hectolitre 4 decalitres each time, how many journeys will he have to make, and how many litres will he carry in the last trip?

EXERCISES ON CHAPTER VIII.

1. Read the following numbers: (1) 27·75 kilogrammes; (2) 0·007 grammes; (3) 121·0003 kilogrammes; (4) 0·0032 kilogrammes; (5) 7·27 hectogrammes; (6) 0·002789 myriagrammes.

2. Write down and add together 12 kilogrammes 75 grammes; 227 grammes 6 decigrammes; 3 hectogrammes 92 centigrammes; 3 myriagrammes 6 hectogrammes 8 grammes; 2,734 grammes. Give the answer in (*a*) kilogrammes and (*b*) grammes.

3. How many milligrammes are there in: (1) 1 decagramme; (2) 876 decagrammes; (3) 11 grammes; (4) 786 grammes; (5) 2 decigrammes; (6) 4 centigrammes?

4. A goldsmith has sold the following silver objects: A cup, weighing 527·450 grammes; a small casket, 216·275 grammes; a bell, 115 grammes; a tray, 205·301 grammes. What is the total weight sold?

5. How many kilogrammes are contained in 189 chests, each weighing 29·73 kilogrammes?

6. What is the total weight of a dozen forks and spoons if each weighs 123 grammes 218 milligrammes?

7. Divide 0·963 grammes by 9.

8. If 45 barrels of oil contain together 5,715 kilogrammes, what is the weight contained in each barrel?

Exercises on Chapter IX.

1. Write and add together 27 francs + 157 francs 25 centimes + 757 francs 95 centimes + 2 francs 5 centimes, and from the total subtract 7 times 14 francs and 15 centimes.

2. If an article cost 3·70 francs per kilogramme, what will be the cost of 500 grammes?

3. A piece of silk contains 73 metres 25 centimetres. If the silk cost 5·25 francs per metre, what will be the cost of the whole piece?

4. A piece of stuff cost 135 francs, and the stuff is at the rate of 2·25 francs per metre. How many metres are there in the piece?

5. What will be the interest on a sum of 7,875·85 francs at the rate of 3·65 per cent. per annum for 227 days?

6. An estate containing 45 hectares 12 ares 15 centiares has been sold at the rate of 2,700·65 francs per hectare. What was the price paid for the whole estate?

7. If 1 kilogramme of coffee cost 4·80 francs, what will be the price of 175 hectogrammes?

8. Divide a sum of 740842·65 francs among 138 persons, and say what will be the share of each person.

9. If 375·50 francs have been paid for 10 steres of wood, what is the price of 1 stere?

10. If 742 kilogrammes 50 decagrammes of something cost 6793·875 francs, what is the price of the kilogramme?

Miscellaneous Problems.

1. Three vineyards have yielded together 4,500 hectolitres of wine. The first produced 1,334 decalitres, the second 14,284 litres. What was the yield of the third?

2. 763 metres of cloth have been given in exchange as an equivalent for 3052 metres of linen. If the metre of cloth cost 8 francs, what is the price of 1 metre of linen?

3. What are (*a*) $\frac{2}{3}$, (*b*) $\frac{3}{4}$, and (*c*) $\frac{4}{5}$ of a metre?

4. What are (*a*) $\frac{1}{3}$, (*b*) $\frac{1}{4}$, and (*c*) $\frac{1}{5}$ of a square metre?

5. How many kilolitres are there in 1,000 kilogrammes of water?

6. How many cubic centimetres are there in 170 centilitres?

7. If the price of the metre is 6 francs, what will be the price of (*a*) 1 decimetre, and (*b*) of 1 centimetre?

8. If 1 decalitre cost 22 francs, what will be the price of (*a*) 1 litre, (*b*) 1 decilitre, (*c*) 1 hectolitre?

9. What is the price of the kilogramme when 29 decagrammes cost 12·25 francs?

10. If a man buys 12 litres of beer at the rate of 12 francs the hectolitre, what must he pay for them?

11. With $\frac{1}{9}$ of his profits a merchant has bought a small estate, for which he paid 28,675 francs. What was his total profit?

12. A wine merchant has received 80 casks of wine, each containing 228 litres. Each cask costs him 96 francs, the freight per cask is 7·25 francs, the extra duties 42 francs, and the cartage to the cellars 0·75 francs. If he sells the wine at the rate of 0·75 francs per litre, what will be his net profit?

13. Three-fourths of an estate are worth 95,400 francs. What is the value of the whole?

14. How many wire nails (French nails), 0·045 metres long, can be made out of a piece of wire 47·43 metres long?

15. What is the weight, in grammes, of a cubic centimetre of gold, if 1 cubic decimetre of it weighs 19·5617 kilogrammes?

16. A vessel full of water weighs 25 kilogrammes. What is its capacity in cubic decimetres if the empty vessel weighs 5·50 kilogrammes?

17. If the specific weight of sea-water is 1·0263 when that of ordinary water is 1, find the weight of the sea-water contained in a cask the contents of which are 3 hectolitres 45 litres.

18. A person owing a sum of 5,600 francs has paid firstly $\frac{2}{3}$ of it, then $\frac{1}{5}$. How much remains due?

19. If 1 litre of water weighs 1 kilogramme, and 1 litre of Burgundy wine 0·9915 kilogrammes, what will be the weight of the wine contained in two casks the contents of which are respectively 2 hectolitres 28 litres, and 2 hectolitres 32 litres?

20. The width of a picture is equal to $\frac{7}{11}$ of its height. If the width is equal to $\frac{4}{7}$ of 2·73 metres, what is the height?

21. If the price of the litre is 0·95 francs, what will be the price per gallon in English money if £1 = 25·18 francs?

22. Four persons are to divide among themselves a certain sum of money, so that the first shall have 1,200 francs, the second as much as the first and third, the third as much as the first and fourth, and the fourth 800 francs. What is the share of each and the total sum divided?

23. If 25 hectares 25 ares of land have been sold for 164,125 francs, what is that per acre in English money, assuming £1 sterling to be worth 25·20 francs?

24. How many kilogrammes of iron are wanted to shoe 540 horses for a whole year, if, on an average, each shoe weighs 29 decagrammes and lasts 1 month?

25. A garden, 44 metres long by 36 wide, is surrounded by an iron railing composed of 480 square bars of iron, the side of which is equal to 0·04 metres and the height to 3 metres. The bars are fixed in three horizontal bars of iron 0·07 metres wide and 0·02 thick. What will be the price of the railing, if a cubic decimetre of iron weighs 7 kilogrammes and if the price of the metal and workmanship amount together to 14·25 francs per 100 kilogrammes?

26. Two couriers start together, the one from Paris, the other from Rome. If the first travels at the rate of 45 kilometres per day and the other at the rate of 40, find the distance between the two towns, knowing that the men meet at the end of the 20th day.

27. What is the value in francs and centimes of £27,325 18*s.* 9*d.*, if £1 is worth 25·28 francs?

28. What will be the cost of a dozen planks 5 metres 35 centimetres long by 45 centimetres wide, if the square metre is to be sold at the rate of 3·85 francs?

29. A sum of 6,650 francs is composed of an equal number of 40-franc pieces, 20-franc pieces, 5-franc pieces, 1-franc pieces, and 50-centime pieces. How many are there of each value?

30. What is the height of the steeple of a church above the road, if it is ascended by 372 steps each 16 centimetres high, if the height of the steeple above the last step is 770 centimetres?

31. If 36 metres of cloth cost 378 francs, for how much must they be resold so as to gain 6 francs on 40 francs?

32. If the paving of a road 17,500 metres long by 4 metres wide has cost 310,304·40 francs, what is the cost of a square paving-stone, the side of which is 16 centimetres?

33. What is the height of a tower, if the shadow it projects is equal to 75 metres, whilst at the same time a pole 5 metres high casts a shadow 9·25 metres long?

34. If 9,375 francs have been paid for a piece of ground the area of which is 625 square metres, what must be the side of a square plot of land which has cost 2,535 francs, assuming both to be sold at the same rate?

35. Find the width of a room the floor area of which is 63 square metres, knowing that if the room were a square one the floor area would be 81 square metres.

36. An avenue 2·565 hectometres is planted with two rows of trees, on each side. Find the number and price of those trees, knowing that they are 6·75 metres apart, that there is a tree at the beginning and the end of each row, and that each tree costs 2·40 francs.

37. If on a plot of land, of an area equal to 1 hectare, snow has fallen to a depth of 15 centimetres, what is the number of hectolitres of water yielded by that snow, if 10 litres of snow give about 1 litre of water?

38. A rectangular hall 8·25 metres long by 5·60 metres wide has been paved with stones 0·25 metres by 0·16 metres; the paving cost 504·85 francs. If the workmanship was reckoned at the rate of 2·25 francs per square metre, find the cost of 100 paving-stones.

39. If the side of a triangular field is 96·50 metres long, and the perpendicular falling on that side 32·40, find its area in acres. (The area of a triangle is equal to the product of one side by half the perpendicular falling on that side from the opposite angle.)

40. A class-room is 9·75 metres long and 6·36 metres wide. What height must it be so that 50 children, and 2 masters, may have 4 cubic metres of air to breathe?

41. A baker has bought 12 sacks of flour weighing 161·75 kilogrammes each, for the sum of 679·35 francs. What price is the flour per 100 kilogrammes?

42. A train running between two places $227\frac{1}{2}$ miles distant from each other covers the distance in 5 hours. (*a*) How much is that per hour in kilometres? and (*b*) what is the total distance in myriametres?

43. What is the weight of salt contained in a cubic metre of sea-water, if 1 litre contains 0·26 kilogrammes of salt?

44. How many panes of glass 35 centimetres by 47 centimetres will be required to glaze the windows of a house, if the total surface of glass they will contain is 365·519 square metres?

45. If a man rides a bicycle at the rate of half a decametre per second, how long will it take him to cover 100 miles (5 miles to be equal to 8 kilometres)?

46. In the space of 121 days a steam-engine has consumed 851,950 kilogrammes of coal by working 12 hours per day. However, as the result of an improvement, the consumption of coal has been reduced to 2,960 kilogrammes in 37 hours. Find the annual saving effected, supposing the engine works during 330 days and that coal costs 1·95 francs per 100 kilogrammes.

47. If oil weighs 0·912 kilogrammes per litre, how many litres will there be in 14·82 kilogrammes?

48. Find the interest on a sum of 22,787 francs at 3·75 francs per cent. for 178 days, and give the result in English money, taking the sovereign at 25·31 francs.

49. If a gas-burner consumes 100·35 cubic decimetres of gas per hour, what will be the yearly consumption of 350 such burners, if on an average they are kept burning for 7 hours every night throughout the year? and what will be the cost if the hectolitre of gas costs 0·27 francs?

50. If 10 men working 8 hours per day for 35 days have dug a trench 42 metres long by 4·25 metres wide, and 2·80 metres deep, how deep could 12 men working 9 hours a day for 36 days dig a trench 54 metres long by 3 wide, supposing the strength of the men in the first gang were to that of those in the second as 2 is to 3, and that the hardness of the second kind of soil is to that of the first as 5 is to 4?

ANSWERS

Answers to Exercises on Chapter III.

1. (1) 0·7.
(2) 0·07.
(3) 0·000007.
(4) 32·027.
(5) 3·27.
(6) 7·3.
(7) 0·0827.
(8) 7·004.
(9) 337·475.
(10) 1.

2. (1) 3 units and 75 hundredths.
(2) 22 units and 75 thousandths.
(3) 637 units and 4 thousandths.
(4) 2 hundredths.
(5) 789 hundred thousandths.
(6) 275 units and 3,214 ten thousandths.
(7) 3 ten thousandths.
(8) 17 units and 8 hundredths.
(9) 200 units and 75 thousandths.
(10) 5 units and 70,203 millionths.

3. Multiplied by 10:—
(1) 37·5.
(2) 220·75.
(3) 6,370·04.
(4) 0·2.
(5) 0·0789.
(6) 2,753·214.
(7) 0·003.
(8) 170·8.
(9) 2,000·75.
(10) 50·70203.

By 1,000:—
(1) 3,750.
(2) 22,075.
(3) 637,004.
(4) 20.
(5) 7·89.
(6) 275,321·4.
(7) 0·3.
(8) 17,080.
(9) 200,075.
(10) 5,070·203.

Divided by 100:—
(1) 0·0375.
(2) 0·22075.
(3) 6·37004.
(4) 0·0002.
(5) 0·0000789.
(6) 2·753214.
(7) 0·000003.
(8) 0·1708.
(9) 2·00075.
(10) 0·05070203.

Divided by 10,000:—
(1) 0·000375.
(2) 0·0022075.
(3) 0·0637004.
(4) 0·000002.
(5) 0·00000789.
(6) 0·02753214.
(7) 0·00000003.
(8) 0·001708.
(9) 0·0200075.
(10) 0·0005070203.

4. (1) 0·2 is 2 tenths and 0·02, 2 hundredths.
   (2) no difference.
   (3) 3·4 is 3 units and 4 tenths and 3·004, 3 units and 4 thousandths.
   (4) 0·5 is 5 tenths and 0·05 five hundredths.
   (5) 75·075 is 75 units and 75 thousandths, and the other is a whole number.

5. (1) 2,612·382389. (2) 450·92888208.

6. (1) 9,574·2417. (2) 2,045·68898. (3) 1,110·088179. (4) 0·00001. (5) 0·0000001.

7. (1) 444·00378. (2) 38·5508201. (3) 1·160435. (4) 0·00070242. (5) 44·255523249. (6) 1. (7) 0·0048072. (8) 144·1442002. (9) 0·0000000002. (10) 0·0001.

8. (1) 2·9312. (2) 1·2345. (3) 27·12347. (4) 0·901174. (5) 4·82. (6) 0·000104. (7) 7·8121. (8) 8·73094. (9) 0·13929. (10) 39·9673.

9. (1) 0·5. (2) $0{\cdot}\dot{6}$. (3) 0·75. (4) $0{\cdot}8\dot{3}$. (5) 0·875. (6) $0{\cdot}\dot{8}\dot{1}$. (7) $0{\cdot}3\dot{1}0\dot{8}$. (8) 0·54768392. (9) $2{\cdot}\dot{2}\dot{7}$. (10) $7{\cdot}\dot{5}7142\dot{7}$.

10. (1) $\frac{5}{37}$. (2) $\frac{370}{481}$. (3) $4\frac{6}{37}$. (4) $\frac{1}{3}$. (5) 1. (6) $\frac{4}{11}$. (7) $\frac{5}{18}$. (8) $\frac{8}{15}$. (9) $\frac{16}{27}$. (10) $\frac{120}{404}$.

Answers to Exercises on Chapter IV.

1. (1) 8,345·7. (2) 9470·075. (3) 35,000·93. (4) 27005·35. (5) 1202·5.

2. (1) 230000. (2) (*a*) 700. (*b*) 7,000,000. (3) (*a*) 14,000,000. (*b*) 1,400. (4) 73. (5) (*a*) 1234·567. (*b*) 123·4567. (*c*) 12·34567.

3. (1) 10. (2) 10,000. (3) 10,000,000. (4) 1,000,000. (5) 1,000.

4. (1) $\frac{1}{10000}$. (2) $\frac{1}{100000000}$. (3) $\frac{1}{100}$. (4) $\frac{1}{10}$. (5) $\frac{1}{10000}$.

Answers to Exercises on Chapter V.

Part I.

1. (1) 1 metre 111 millimetres.
   (2) 2 metres 22 millimetres.
   (3) 3 metres 3 millimetres.
   (4) 1 millimetre.
   (5) 50 centimetres, or 5 decimetres. (50 centimetres is more commonly used.)
2. 13 kilometres 567 metres.
3. (1) 0·01. (4) 1707.
   (2) 0·004. (5) 3·25.
   (3) 0·5.
4. (1) 18·250 kilometres, or 18,250 metres.
   (2) 6·50 metres. (4) 0·025.
   (3) 0·05 metres. (5) 0·0005.
5. 9·95 metres.
6. 8·98 metres.
7. 12·336 metres.
8. 9·1875 kilometres, or 9187·50 metres.
9. 228·6̇1 metres.
10. 7328·125 metres or 7.328125 kilometres.

Answers to Exercises on Chapter V.

Part II.

1. 291 metres.
2. 1,512 metres.
3. No difference.
4. 175·563 kilometres.
5. 150 kilometres and 1 hectometre, or 150·1 kilometres.
6. 280090 metres.
7. 189997·50 metres.
8. 4·68 metres.
9. 43.75 metres.
10. 0·15 metres.

ANSWERS TO EXERCISES ON CHAPTER VI.

PART I.

1. (1) 27 square metres 72 square decimetres.
   (2) 3 square decimetres.
   (3) 29 square millimetres.
   (4) 5 square metres 2,070 square centimetres.
   (5) half a square metre, or 50 square decimetres.
2. (1) 0·0001. (2) 0·000007. (3) 0·0192. (4) 0·5. (5) 0·005.
3. 183·7517 square metres.
4. 0·279766 square metres.
5. (*a*) $\frac{2}{10}$ of a square metre = 0·2; 2 square decimetres = 0·02. Therefore 2 square decimetres are 10 times smaller than two-tenths of a square metre.
   (*b*) 3 square centimetres are 100 times smaller than the three-hundredths of a square metre.
6. 3,966·76704 square metres, that is 3,966 square metres 767,040 square millimetres.
7. (*a*) 270·215, that is 270 square metres and 2,150 square centimetres.
   (*b*) 27,021 square metres and a half.
8. (*a*) 6 square metres 278,990 square millimetres.
   (*b*) 0·627899, that is 627,899 square millimetres.
9. 0·0784. 10. 634·038461 square metres.

PART II.

1. 4·68.
2. 67·65 square metres.
3. 820·05 square metres.
4. 47·2485 square metres.
5. 21·1640 square metres.

Answers to Exercises on Chapter VI.

1. (1) 15 hect 2 ares 37 centiares.
   (2) 27 hect. 81 ares 45 centiares.
   (3) 1 hect. 79 ares 7 centiares.
   (4) 2 hect. 18 ares 97 centiares.
   (5) 1,119 hectares 50 ares.
2. (1) 2·1517 hectares.
   (2) 0·1299 hectares, or 12·99 ares.
   (3) 8·0003 hectares.
   (4) 2·0199 hectares.
   (5) 0.0505 hectares, or 5·05 ares.
   (6) 1·2809 hectares.
   (7) 15·0027 hectares.
   (8) 106·11 hectares.
   (9) 2·2703 hectares.
   (10) 27,000·0097 hectares.
3. 15·5556 hectares, or 15 hectares 55 ares, 56 centiares.
4. (1) 1.
   (2) 19·27.
   (3) 2·1178.
   (4) 20·0304.
   (5) 234·5678.
   (6) 23456·78.
5. (1) 10,000.
   (2) 2,700.
   (3) 112,700.
   (4) 2,340,000.
   (5) 1,234.500.
6. 519·41 ares.
7. 776·7208 hectares.
8. 93·1845 hectares.
9. 429·2947 hectares.
10. 235·6110 hectares.

Answers to Exercises on Chapter VII.

1. (1) 15 cubic metres 631,213 cubic centimetres.
   (2) 3,667 cubic centimetres.
   (3) 3 cubic metres 1,234,567 cubic millimetres.
   (4) 7 cubic millimetres.
   (5) 77 cubic metres and 300 cubic decimetres.
   (6) 21 cubic metres and 23,400 cubic centimetres.
   (7) 10 cubic decimetres.
2. (1) 3·075.
   (2) 73·000793.
   (3) 0·000000212.
   (4) 0·0025.
   (5) 0·5, or 0·500.
   (6) 0·0000005.
3. 3·715579216 cubic metres.
4. 1·044998.
5. 1228·5.
6. 72,381.
7. 24·25 steres, or 24 steres 2 decisteres and a half.
8. 1773·65.
9. 60 steres 2 decisteres.
10. 2·49 etc. steres, or very nearly 2 steres and a half.

Answers to Exercises on Chapter VII.

1. (1) 2800. (2) 50. (3) 1·27. (4) 37·24. (5) 960. (6) 151·75.
2. (1) 2·734. (2) 27·3. (3) 70. (4) 32·45.
3. 1,243·32 litres, or 12·4332 hectolitres. 4. 2,421·25.
5. 12,148 2 hectolitres. 6. 2,188·8 hectolitres. 7. 420.
8. 565 journeys. He will carry 90 litres in the last trip.

Answers to Exercises on Chapter VIII.

1. (1) 27 kilogrammes 75 decas.
   (2) 7 milligrammes.
   (3) 121 kilogrammes 3 decis.
   (4) 32 decigrammes.
   (5) 7 hectos. 27 grammes.
   (6) 27 grammes 89 centis.
2. (*a*) 45·94552 kilogrammes. (*b*) 45,945·52 grammes.
3. (1) 10,000. (2) 8,760,000. (3) 11,000. (4) 786,000. (5) 200. (6) 40.
4. 1,064·026 grammes. 5. 5,618·97 kilogrammes.
6. 2,957·232 grammes. 7. 0·107 grammes. 8. 127 kilogrammes.

Answers to Exercises on Chapter IX.

1.
```
        27
       157·25
       757·95
         2·05
       ------
Total . 944·25 francs.
```
7 times 14·15 francs are:—
```
        14·15
            7
       ------
        99·05 francs.
```
Subtraction :—
```
       944·25
        99·05
       ------
       845·20 francs.
```
2. 1.85 francs.
3. 384·60 francs.
4. 60 metres.
5. 178·80 francs.
   (Really 178·7817, etc.)
6. 121,857·40 francs.
7. 84 francs.
8. 5,368·425 francs, that is 5.368·45 francs.
9. 37·55 francs.
10. 9·15 francs.

ANSWERS TO MISCELLANEOUS PROBLEMS.

1. 422·376 hectolitres.
2. 2 francs.
3. (*a*) 0 666 etc. mm.
   (*b*) 0·75 metres.
   (*c*) 0·8 decimetres.
4. (*a*) 0·333333 etc. sq. m.
   (*b*) 0·25 sq. m.
   (*c*) 0·20 sq. m.
5. 1 kilolitre.
6. 1700.
7. (*a*) 0·60 francs.
   (*b*) 0·06 francs.
8. (*a*) 2·20 francs.
   (*b*) 0·22 francs.
   (*c*) 220 francs.
9. 42·25 francs.
10. 1·45 francs.
11. 258075 francs.
12. 2,000 francs.
13. 127,200 francs.
14. 1,054.
15. 19·5617 grammes.
16. 19·5 c decimetres.
17. 354·0735 kilogs.
18. 746·66 francs, that is 746·65 francs.
19. 456·09 kilogs.
20. 2·451 metres.
21. A little over 3*s*. 5*d*.
22. 1st, 1,200; 2nd, 3,200; 3rd, 2,000; 4th, 800 francs. Total sum = 7,200 francs.
23. £104 7*s*. 7*d*.
24. 7,516·8 kilogs.
25. 2,968·55 francs.
26. 1,700 kilometres.
27. 690,799·65 francs
28. 111·25 francs.
29. 100 of each kind.
30. 67·22 metres.
31. 434·70 francs.
32. A little more than 11 centimes apiece, that is 0·11 franc.
33. 40·54 metres.
34. 13 metres.
35. 9 metres.
36. 156 trees, 374·40 francs.
37. 1,500 hectolitres.
38. 34·70 francs per hundred (very slightly over that).
39. 15 ares 63 centiares (and a fraction 0 3).
40. 3·354, etc. metres.
41. 35 francs.
42. (*a*) 72·8 kilometres per hour.
    (*b*) 36·4 myriams.
43. 260 kilogrammes.
44. 2,222.
45. 8 h 53 m. 20 s.
46. 39,130·65 francs.
47. 16·25 litres.
48. £16 9*s*. 3½*d*
49. (*a*) 897,379·875 hectolitres.
    (*b*) 242,292·56, etc. francs.
50. 5·141 metres (exactly 5·1408).

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PLYMOUTH
WILLIAM BRENDON AND SON, PRINTERS